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THE LAND AND WILDLIFE

EDWARD H. GRAHAM

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TO THE BIOLOGISTS

OF THE

SOIL CONSERVATION SERVICE

PREFACE

THIS BOOK was written to make a point. The point is that the most practical wildlife management is accomplished through good land use. *The Land and Wildlife* builds its case largely on land-use practices applicable to agricultural land, although the principle applies to other lands. It does not attempt to explain in detail how to apply such practices, for regional and local conditions call for varying specifications. It does describe practices, indicates how they fit into schemes of wise land use, and tells something of what they mean to wildlife.

The abundance of wildlife does not result from jurisdiction, sportsmen's meetings, or bureaucratic dictates; it results from what we do with the land. And what is done with the land must fit the land, and contribute to the needs of those who live upon it. The wildlife technician will find many of his favorite tricks missing in this book, but the practices reviewed have the sound recommendation that they are good for the land, and are actually being applied. They are being followed by an ever-increasing number of land operators who are becoming more and more conscious of their own relation to the soil and who recognize that careful husbandry is the one real assurance of future security.

We want wildlife in America because it affords recreation to millions of people, because it provides a very substantial economic return to a great many others, and above all, perhaps, because it is a valuable heritage and an expression of a national house in good order. Wildlife flourishes where man has succeeded in adapting himself to the land on which he lives and where he has attained a degree of bountiful living. Wild birds and mammals are not abundant where man and the land are not in harmony, where

man must use the land so intensively as to extract every last talent from it.

The conservation of wildlife in America is no luxury, any more than the conservation of our soil is a luxury. We might do without topsoil, but only as we were willing to accept a very low standard of living and a precarious future. We could do with less wildlife, but would be a poorer nation without it. Hunting and fishing, profit in the till from the wildlife harvest, aesthetic appreciation of wild creatures by those who neither kill nor profit—all these are traditional in America. Yet none of these things, in themselves, so convinces us of the value and necessity of wild animals as the knowledge that without them something would be fundamentally wrong, seriously out of order. We want wildlife not only for its immediate usefulness, but also for the part it has played in our civilization and the influence it exerts upon us and the environment of which we are a part.

Once protection is established and the harvest is regulated, as they have been for generations in the United States, the use of the land is the controlling factor in wildlife welfare. Attention to wet lands, streams and streambanks, ponds, field borders, windbreaks, hedges, and odd infertile and eroded areas is a necessary part of farm and ranch management, and it would be difficult to enumerate specific habitat elements that can be made more useful to wildlife. The practices applied to cropland, pasture, and woodlot to assure soil and water conservation, together with sound management of forests and range land, are also of major value to wildlife. Attention to all these adds up to the interesting conclusion that wildlife benefits more from land management than it does from wildlife management. This is true, of course, because quail, or grouse, or muskrats, or any other wild creature first of all needs a suitable place in which to live.

It may be well to explain that the term wildlife is here used in a restricted sense to mean wild vertebrate animals, chiefly fish, birds, and mammals.

For preparing the Plates in the book, photographic prints were

freely obtained from several sources. The U.S. Department of the Interior furnished the lower picture in Plate 9. The Fish and Wildlife Service of the same Department provided the bottom left pictures in Plates 3, 7, and 16, the bottom right pictures for Plates 15, 16, and 25, and the bottom pictures for Plates 5 and 28. Plate 10, bottom, is from the Indiana Department of Conservation, and the top picture for Plate 10 is from the 41st Division, Washington National Guard. The U.S. Forest Service supplied the top pictures for Plates 3 and 25, bottom right for Plate 3, bottom left for Plate 25, and the bottom picture for Plate 21. All other pictures except the three mentioned in the following paragraph are from the U.S. Soil Conservation Service.

For permission to reproduce from Henry Fairfield Osborn's *Men of the Old Stone Age* the prehistoric cave mural of the extinct European bison, I am indebted to Charles Scribner's Sons, New York. Duell, Sloan, and Pearce of New York kindly granted permission to reproduce the picture of the turkey on the 1280 German church, from the book *Westward from Vinland* by Hjalmar R. Holand. For permission to copy from Martin S. Garretson's *The American Bison* the reproduction of the first printed likeness of the American bison, I am indebted to the New York Zoological Society, New York.

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Conference. The *Audubon Magazine, American Forests,* and *Nature Magazine* permitted quotations from recent numbers. The Michigan Department of Conservation permitted use of a passage from Allen's *Michigan Fox Squirrel Management* and the Brookings Institution granted use of quotations from Cameron's *The Bureau of Biological Survey.* The Philadelphia Society for Promoting Agriculture permitted use of material from early publications of the Society. Arthur H. Clark Company gave permission to quote from Hulbert's *Historic Highways of America,* and the University of Chicago Press granted use of material from Luckenbill's *Ancient Records of Assyria and Babylonia.* Bentley House granted use of a quotation from Darby's *The Draining of the Fens,* and Macmillan allowed quotations from Gabrielson's *Wildlife Refuges.* The Country Gentlemen's Association and W. Strahan, both of London, permitted use of quotations from *Game and Game Coverts* by Simpson and Blackstone's *Commentaries on the Laws of England* respectively.

For help in the writing of this book I am indebted to many friends. To William R. Van Dersal I am forever grateful. Critical review was given the manuscript by Richard M. Bond, Philip F. Allan, Frank C. Edminster, Verne E. Davison, and Lawrence V. Compton. Wellington Brink's editorial pencil contributed materially. Julianne S. Carrol helped with the typing and Hermann Postlethwaite assisted in the selection of the illustrations. Mary B. Graham aided immeasurably as always.

E. H. C.

Tuliptrees
Falls Church, Va.
November 1946

CONTENTS

THE LAND AND WILDLIFE

I ⇝ WILDLIFE HERITAGE

Cultural Debt

Man's earliest association with animals must have been one he could not avoid, for undoubtedly he had many reasons to shun wild beasts. It is easy to imagine that primitive man was forced to encounter wild birds and mammals whether he wanted to or not. Having no utensils, he must have lived close to water so he need not carry it, and at springs, streams, and lakes he and the other animals of his time must have sought water to drink. Perhaps this is where he first killed an animal. Man must have learned a lot about animals then—about their comings and goings, how to avoid them, or how to drive them off.

Before he had learned to hunt and fish, man probably did not use animals much for food or clothing. How long a time elapsed before our ancient ancestors, becoming accustomed to animals through accidental and enforced association, first took it upon themselves to kill a large mammal, no one can say. Perhaps, in one way or another, they were encouraged by the killing of smaller game. Man devised ways of successful hunting long before he discovered how to grow grain from seed. He was a hunter before he became a farmer—long, long before—and he had a history of intimate experiences with animals before he thought much more of plants than he thought of the rocks or the rain.

During the late glacial periods in Europe man was forced into

caves, where he sought shelter from a climate of increasing severity. At that time the woolly rhinoceros, musk ox, bison, and reindeer were prevalent. And into caves, too, went the cave lion, the cave bear, and the cave hyena. Neanderthal man had only the crudest of weapons, but he did use fire, which must have helped to keep the cave animals from the shelters he chose for retreat. Later, as the glaciers receded, men appeared who knew the use of better weapons, and had many implements of stone. They were hunters, and great artists, and there is some reason to believe that they might have domesticated the horse. These men killed large mammals, which served to provide them with skins for raiment and flesh for food. Enough is known of Stone Age man to tell us that animals influenced not only food and clothing, but also the development of weapons, and later of art. Association with animals also stimulated the adoption of ritual and symbolism, the forerunners of religion.

ART

One of the most fascinating chapters of man's cultural history revolves around the cave art of late Paleolithic man, as it is revealed in the caverns of France and Spain. On the walls and ceilings of those caves are beautiful drawings of at least twenty-five kinds of wild animals, many of them long extinct as inhabitants of southwestern Europe. Among them are graceful, accurate likenesses of reindeer, cave bear, wild cattle, horse, lion, salmon, woolly mammoth, wolf, deer and wild boar, some shown alone, others in groups. Engraved on the rock, modeled in clay, sculptured in high relief, and carved on horns, bones, and teeth, these animal likenesses prove Stone Age man a master of the arts.

Most astounding of prehistoric artistic achievements were the colored paintings, such as those of the European bison or wisent, still brilliantly preserved in the darkness of the Altamira grotto of northern Spain (Plate 1). First engraved on a prepared surface, heavy outlines were then drawn on the rock in black or red, with yellow-brown added for tones representing hairier parts of the

bison. Pigments were mixed with animal oils or fats, giving us at once the birth of oil painting and of polychrome murals. These paintings by present standards are high accomplishment in the field of art (Osborn 1923). All of this by men whose best weapons were stone implements, who had no domesticated plants and probably no tamed animals, and who lived so long ago that some of the species they depicted never survived to be seen even by the oldest of modern men.

Within our own country prehistoric men took great satisfaction in portraying animals, and they have left their records to prove it. Although from an artistic standpoint they are comparatively crude, the chipped characters made by early men on the side walls of Utah's northern canyons show unusual interest in wild animals. The antiquity of these pictographs is shown by the fact that one of the animals most commonly carved is the wild turkey, a species now extinct in that region. In some of these pictographs turkeys are shown being driven by men into corrals. The deer was also commonly carved, as were elk, mountain sheep, and occasionally bison. The antelope, later common in the area, was not represented. Does the roster of species, one wonders, suggest a more moist climate then, with trees occurring more abundantly at lower elevations than they do now?

Between the recorded use of wildlife by ancient man and historic chronicles there is a vast hiatus. Long after the first primitive art we find animals next recorded in early sculpture and architecture of the Old World. It is interesting that civilizations of the Nile and Euphrates have left us less of domesticated animals, like the horse and dog, than they have recorded species selected for their symbolic character and ornamental possibilities. Down to the present time, the animals most used in architectural ornament have been the lion, panther, tiger, eagle, and dolphin. To a lesser extent, the horse, goat, ox, aurochs, serpent and other animals have been employed, especially their heads. Inevitably, imaginative men combined various animals or their parts to produce fantastic creatures. Hence the griffin—lion's body with head and

wings of an eagle—symbol of wisdom and watchfulness; the sphinx—lion and woman—guardian of temples and tombs; the centaur—horse and man; and the chimera, with lion's head, goat's body, and serpent's tail.

Among animals used for ornamental design the lion holds first place. Tales of lion hunts come down to us from the palace walls of the Assyrian kings, while the Egyptians idealized the lion in art until it was almost unrecognizable. The Greeks and the Romans associated the lion with springs, gates, and temples, both in ornament and ritual. The sleeping lion was the symbol of the fallen hero. In early Christian art the lion represented various things—the emblem of the Redeemer or the symbol of evil. Later, as a result of the Crusades, the lion became the most common figure of heraldry, and today it is still conspicuous in the field of decoration. The head of the lion especially is found on gargoyles, door knockers, vessel spouts, fountains, furniture, and as countless other decorative elements. Second only to the lion is the eagle. From the earliest times—Persian, Assyrian, Egyptian—the eagle has had a place in art, mythology, and religion. Excepting the lion, the eagle is the most used heraldic creature, the national emblem of many countries, including the United States.

Among other animals the dolphin—a mammal of the sea—holds a high place in decorative art, as do the scallop shell, conch, and the serpent, which was used so widely in the Americas as well as in the Old World. To the most spectacular of aboriginal American architecture, that of the Mayans, wild animals gave conspicuous character. The snake is everywhere on Mayan buildings, while other species—lizard, rabbit, eagle—occupy prominent places. The Old World lion, of course, was absent, but the New World lions—puma and jaguar—took its place. The jaguar and snake were combined in American counterparts of the fantastic creatures of the Old World. In Eskimo art also, as in ivory carvings, native animals are conspicuous. Even today, in modernistic design, the features of wild creatures—realistic and conventional—play an important part in painting, sculpture, and architecture (Plate 1).

DOMESTICATED ANIMALS

Another broad aspect of human culture for which we are not only indebted to wildlife, but in large measure dependent upon it, is the development of domesticated animals from wild species. As already noted, glacial man may have tamed the horse, although we cannot be sure. We inherited the horse, as well as most of our other domesticated animals, from Europe, or at least from the Old World. In addition to the horse, we obtained cattle, sheep, goat, swine, water buffalo, yak, camel, goose, duck, chicken, guinea hen, and pigeon from the Old World. From South America came only the llama, alpaca, muscovy duck, and guinea pig, and from Mexico the turkey. The dog was the one domesticated animal common to the two hemispheres. The evolution of domesticated animals is a long and interesting story and, as Shaler (1895) wrote in his excellent book on the subject:

> . . . when we consider the enlargements of resources and the diversification of industries which rest upon the adoption of any one of these animals—as for instance, the horse—we see in a way what the possession of domesticated animals and plants really means, and are in a position to conceive, though at best but dimly, what the scores of these captive species have done for us.

Through domestication we have obtained not only beasts for burden-bearing, food, and raiment, but many animals used in sports, such as racing and polo, and in entertainment, such as the circus and bullfight. Some animals, as the peacock and swan, we value for pure ornament. We have also inherited pets through the taming of wild beasts. It is of interest that the Aztecs had gathered together many wild animals in a great menagerie for Montezuma in Mexico City, although they had few domesticated beasts. These caged animals were pets of a sort, collected for the amusement and satisfaction of the ruler. Perhaps animals were tamed first as much for pets and companions as for more useful purposes, although the origins of domesticated animals, like those

of cultivated plants, are obscure. It is possible that some animals became domesticated through habitual association with man. Others may have become so through being at first captured for the food they provided. Domestication of animals puts civilization in permanent debt to wildlife and supplies a firm supporting reason for its conservation.

It is conceivable that the early curiosity about animals that led to their taming and domestication had many special results no longer associated with them. It must have helped to develop a sense of property and an increased responsibility for the care of the household. The use of animals by certain groups of people permitted ascendancy over those who did not possess them and facilitated the art of war. Their care must also have had much to do with conditioning man to a less nomadic way of life, in which the cultivation of crops came naturally as he discovered that he could grow plants for their edible seeds. The interest in animals opened men's minds to all the things about them, giving rise not only to natural history but to the development of other fields of science as time went on. A number of tame animals, such as the guinea pig, hamster, white mouse, and rat, are extensively used in experimental medicine, millions of them serving science in the United States each year. Today we are studying wild animals, especially the social species, to learn what we can of their behavior. What we learn may give us hints on how better to orient our own society.

OTHER VALUES

It is not alone in art and domestication that wild animals help shape our lives. It is, in fact, difficult to avoid their influence. As already suggested, animal symbolism is very old. It is common in the Bible. Early Greek poetry is full of it. The lamb of God, the serpent in the Garden of Eden, the dove and the ark, Jonah and the whale, and many other Biblical allegories prove man's long familiarity with the animal life of the earth. Aesop's Fables are often told through wild creatures, while nursery rhymes and

fairy tales, many of them very old, tell of beasts and birds. *The Jungle Book, Bambi, Black Beauty,* and many other stories written about animals are perennial favorites. *Alice in Wonderland* would lose much of its charm without the cat, the walrus, the hare, the oyster, and the dormouse. Animal symbolism contributes richness to expression and familiar touches to allegory and metaphor, as wild creatures continue their steady contribution to this portion of our cultural life. Even the modern motion picture, technical marvel that it is, finds some of its popularity in Mickey Mouse and a dozen similar characters.

In many other aspects of everyday living we are indebted to wildlife. From time immemorial the stars in the sky took form as animals. The constellations: Great Bear—*Ursa major;* Little Bear —*Ursa minor;* the Scorpion—*Scorpio;* Crow—*Corvis;* Ram—*Aries;* Dragon—*Draco;* Swan—*Cygnus;* Eagle—*Aquila;* Giraffe—*Camelopardalis;* the Fishes—*Pisces;* Winged Horse—*Pegasus;* Lion—*Leo;* Serpent—*Serpens;* Lesser Dog—*Canis minor;* and Sea Monster—*Cetus* are familiar to all who know the northern skies. In the south, the Wolf—*Lupus;* Centaur—*Centaurus;* Crane—*Grus;* Phoenix—*Chameleon;* Hare—*Lepus;* Dog—*Canis major;* Goat—*Capricornus;* and Peacock—*Pavo* are conspicuous. Among the twelve signs of the zodiac, seven are animals and another is a fantastic beast, the centaur.

The British lion, American eagle, and Russian bear are familiar characters in cartoons of the day. Although our enemies are sometimes caricatured as beasts, they are more often shown as degenerate or monstrous men than as animals. In modern advertising birds and mammals play a conspicuous part; often they are the symbol of the product. It is surprising, in this day of helicopters, television, plastics, atomic energy, radar, and jet-propelled planes, that so many advertisers use animals for popular appeal. Many brands of foods and other products bear animal names. Leafing through our magazines proves how true this is. Our baseball and football teams frequently assume names of birds and mammals.

The purely economic values of wildlife are reserved for treat-

ment in another chapter, but cultural values must include mention of the influence of the beaver and other furbearers in the opening and development of the Far West. In Canada the Hudson Bay Company, founded upon trade in fur resources, has for four hundred years contributed much to the development of the North. The marks of quality or points on a Hudson Bay blanket still remind us that its value was originally scored in prime beaver skins. In the United States the search for furs helped chart the westward course of empire. Exploration and wildlife are intricately related. Wild animals also yielded food and clothing for the pioneer.

WILDLIFE AND AMERICAN CULTURE

In the United States we learned very early from the Indians the species of wild animals that could be used for food, clothing, and other utilitarian purposes. Close association with wild creatures was a part of daily living for our early forebears. The buckskin suit, long rifle, and other symbols of the wilderness are full of meaning. As the nation expanded, explorers moved westward over trails that the Indians and, before them, wild animals had defined. Many of our great highways follow courses that buffaloes marked across the land. The buffalo, following migratory paths across the continent, beat well-defined lanes of travel. They had the capacity to choose the easiest grades and most direct courses. They selected the shortest overland portages and the shallowest river crossings. Their routes, or traces, blazed the way for many roads, canals, and rail routes. As Hulbert (1902) puts it:

> The farther back we go in our history, the more conclusive does the evidence become that the first ways were the highest ways. Our first roads were ridge roads and their day is not altogether past in many parts of the land. These first roads were 'run,' or built, along the general alignment of the first pioneer roads, which, in turn, were nothing more than 'blazed' paths of the Indian and buffalo. . .

Undoubtedly the migrations of the buffalo caused the opening of the great overland trails upon which the first white men came into the West.

. . . the New York Central, the Baltimore and Ohio, the Pennsylvania, and the Chesapeake and Ohio cross the first great divide in the eastern portion of our country on routes selected centuries ago by the plunging buffalo.

Place names throughout the land and topographic features familiarly bear animal names. There are counties in the United States commemorating the Eagle (Colorado), Caribou (Idaho), Elk (Kansas, Pennsylvania), Big Horn (Montana, Wyoming), Antelope (Nebraska), Buffalo (Wisconsin, Nebraska, South Dakota), Beaver (Oklahoma, Pennsylvania, Utah), and Kingfisher (Oklahoma). Flags of historic importance, in the United States as elsewhere, have carried animal likenesses. Stamps also, as well as coins, bear images of wild and tame creatures.

Yet the greatest impress wildlife has made upon Americans is an intangible one. We have absorbed from the Indians much in the way of architecture, art, and customs that influence our building, painting, and way of life. What we learned in the way of hunting and fishing and getting along in the wilderness has actually helped to determine the very traits and characteristics that are American. In analyzing the influence of wildlife in American culture, Aldo Leopold (1943) points to three values. The first is that which 'reminds us of our distinctive national origins and evolution,' as the modern boy playing in a coonskin cap re-enacts a phase of American history. There is also value in that which 'reminds us of our dependency on the soil-plant-animal-man food chain,' which we inherit from generations of familiarity with things that are wild. Finally there is an ethical value arising out of this man-earth relation which can teach us that 'we shall achieve conservation when and only when the destructive use of land becomes unethical—punishable by social ostracism.'

Pointing also to two ideas arising from our pioneer experience —the 'go-light' idea of resourcefully traveling alone in the wilder-

ness and the 'one bullet—one buck' idea of expert marksmanship —Leopold writes that, in their later evolution, these values and ideas 'became a code of sportsmanship, a self-imposed limitation on sport,' giving rise to 'a distinctively American tradition of self-reliance, hardihood, woodcraft, and marksmanship.' These are perhaps intangibles, but they are nevertheless vital factors in our national character. Among these characteristics, in fact, are those which set Americans apart and in which we take pride. Our own debt to wildlife and the wilderness, it might well be maintained, has had an effect not only upon our culture, but upon our individuality as well.

The relation between resources and history is reflected in the American personality. Because of the great wealth of natural objects surrounding the colonist, it was easy to believe that wildlife, forests, the land itself, were limitless, inexhaustible. What Cameron (1929) has written of wildlife could as easily have been written of minerals, forests, grassland, or soil. He wrote:

> In a word, it was inevitable that his environment should have bred in the early American settler a fixed idea and a trait. The fixed idea was a conviction that any such thing as the extermination of game was impossible. The trait was a prodigal disregard for not merely game but wildlife of all sorts comparable to the solicitude which the boy with a stick in his hands feels for the weeds by the wayside. And both the trait and the idea were transmitted to the early settler's children and to his children's children. And along with them were transmitted the fierce conviction that the free-born American had the right to bear arms, and to 'gun' pretty much where, when, and how he pleased.

Among other things, this conviction helped us shape a representative government and a democratic way of life.

To summarize the debt of human culture to wildlife we must admit that it is virtually impossible to imagine civilization without domesticated animals, the influence of wild creatures in literature, art, and architecture, and their part in religious and alle-

gorical symbolism. It is no wonder, then, that there is within us something that cries out when wildlife is endangered, as when a species is threatened with extinction, or when marshlands, forests, and other homes for wild birds and mammals are materially changed or destroyed. It is not the voice of the hunter, who loses game to shoot, or the naturalist, who loses a species to study, that alone challenges change, nor should it be. Our whole history as a nation, people, and race depicts in the loss of wildlife an injury to our cultural heritage we cannot easily tolerate. Our original interest—born of ancient men and tribes so long ago—still persists. It is as much a part of us as our instincts, emotions, and habits, and in this interest we find a reason and a challenge for preserving wildlife far stronger than the recreational and economic considerations so often stressed today. Such interests do not loom large to many who deal with wildlife, but they motivate much of what most of us feel when the future existence of a great natural resource is known to be at stake.

Custom and Law

ANCIENT REGULATIONS

In the beginning, wild plants and animals belonged no more to man than to the earth or the elements. Man and all other living things composed a vast complex in which one was no more dominant than the other. As the famous French jurist, Pothier, states in his treatise on the rights of property:

> The first of mankind had in common all those things which God had given to the human race. This community was not a positive community of interest . . . it was . . . a negative community, which resulted from the fact that those things which were common to all belonged no more to one than to the others [Geer *vs.* Conn. 161 U.S. 519].

These were the things in common, the *res communes*—air, water that runs in the rivers, the sea and its shores, and the wild animals, the *ferae naturae*. But man's relation to these things of

nature came to be a problem long before faint glimmers of civilization developed, and in communal groups of the most primitive peoples, natural objects were segregated and given special attention for some quality they possessed that was useful to man.

Many of the earliest taboos of ancient peoples relate to game animals. There is probably no people who have learned to live more successfully in a severe environment, or have become culturally better adapted to difficult conditions, than the Eskimos. Their home is cold and they have only small quantities of very poor fuel. Among the Eskimos almost every detail of hunting and of utilizing the catch is regulated by taboos. The basis of the taboos is that land animals, like the caribou, and water animals, like seal, walrus, and whale, must be kept separate. This is a fundamental conservation measure of great antiquity. It is expressed, among some Eskimos, in the regulation that caribou and seal must not be eaten the same day. Here, then, is a seasonal restriction preserving one species of game when another is more conveniently at hand. The use of fuel gathered from the ground, such as faggots and moss, is prohibited when a whale is captured, for whale oil is used for fuel. Thus every available source of heat is conserved. Among the Copper Eskimos, fresh-water fish, even salmon migrating from the sea, must be cooked only on land, but tomcod caught in the sea, like seals, may be cooked either on the ice or on the land.

But somehow hunting and fishing, through the millenniums of early human history, were gradually transmitted among civilized peoples from the universal vocation to the place where chiefs and rulers usurped them for their own pleasure and excitement. The change must have occurred as man discovered how to tame wild beasts and how to raise food from plants he cultivated, for this threw his dependence upon tilled crops and domesticated animals. At any rate, the earliest written records of game and fish usually describe them as objects of sport. The Egyptians, Assyrians, and Babylonians, so far as we know through scenes depicted on their temples and ancient records, hunted many wild

beasts and devised many special weapons for capturing or killing them. In addition to game hunted in the open, the ancients sometimes enclosed it in parks or preserves.

Occasional bits of evidence indicate that wildlife welfare may have been the subject of much consideration among the ancients. The Assyrian king Sennacherib, who lived seven hundred years before Christ, left an inscription on a building which shows that he established a habitat for wildlife and successfully stocked it with game. The inscription reads (Luckenbill 1927):

I set out a great park, like unto Mount Amanus, wherein were all kinds of herbs and fruit trees, trees such as grow on the mountains and in Chaldea. To increase the productiveness of the . . . fields, from the border of the city of Kirisi to the plain of Nineveh, I cut through the hills . . . ran a canal . . . from the place where the Husur lets down its ancient waters . . . I made [the water] flow through those fields in irrigation ditches. To arrest the flow of the water through . . . those orchards, I made a swamp and set out a cane-brake therein. *Igiru*-birds, wild swine, beasts of the forest, I turned loose therein.

By command of the god, within the orchards, the vine, every fruit-bearing tree, and herbs throve luxuriously. The cypress and mulberry, all kinds of trees, grew large and sent out many shoots [?]; the cane-brakes developed rapidly [mightily]; the birds of heaven, the *Igiru*-birds, built their nests, and the wild swine and beasts of the forests brought forth their young in abundance. . .

Biblical records indicate a kingly interest in the chase, and numerous references allude to the game sought and the weapons used to obtain it. Unlike the records of the Egyptians, Old Testament history does not record the use of the horse in hunting, or of the dog. But it is in the Bible that we find what is probably the earliest stated rule of game management—a restriction on take. It is one of the statutes and judgments composing the Mosaic law, and decrees that:

If a bird's nest chance to be before thee in the way in any tree, or on the ground, whether they be young ones, or eggs, and the dam sitting upon the young, or upon the eggs, thou shalt not

take the dam with the young: But thou shalt in any wise let the dam go, and take the young to thee: that it may be well with thee, and that thou mayest prolong thy days [Deuteronomy 22:6, 7].

The Greeks and Romans also loved the chase, and their literature attests the fact. The Romans possessed some game laws, although none of them dealt with protecting game or improving its welfare. In Asia there seems to have been more interest in managing wildlife. Full two centuries before Columbus set westward sail across the Atlantic, Marco Polo found that Kublai Khan, the Mongol emperor, had established a system of wildlife food patches, winter feeding, and cover control. Marco Polo's chronicler (Komroff 1926), writing about conditions near Changanor, Cathay, records:

At this place the Khan has a great Palace, which he is fond of visiting because it is surrounded with pieces of water and streams, which are the haunt of many swans. There is also a fine plain, where are found in great numbers, cranes, pheasants, partridges, and other birds. He derives the highest degree of amusement from sporting with gerfalcons and hawks, the game being here in vast abundance. . . Near to this city is a valley frequented by great numbers of partridges and quails, for whose food the Great Khan causes millet, and other grains suitable to such birds, to be sown along the sides of it every season, and gives strict command that no person shall dare to reap the seed; in order that the birds may not be in want of nourishment. Many keepers, likewise, are stationed there for the preservation of the game, that it may not be taken or destroyed, as well as for the purpose of throwing the millet to the birds during the winter. So accustomed are they to this feeding, that upon the grain being scattered and the man's whistling, they immediately assemble from every quarter. The Great Khan also directs that a number of small buildings be prepared for their shelter during the night; and, in consequence of these attentions, he always finds abundant sport when he visits this country.

The Great Khan also reputedly maintained one of the largest hunting packs in history—5000 dogs with many men to train

and manage them—and in other ways proved himself a sportsman and one of the earliest of game managers.

ENGLISH BACKGROUND

As in Babylonia and other ancient lands, the Britains in northern Europe bred dogs for hunting purposes, and sport was at first open to everyone except slaves. As the feudal system developed, however, the idea of game preserves took hold, and hunting restrictions in favor of the rulers appeared. The development of this idea in England is worth a few words, for it strongly influences the attitude, laws, and management of wildlife in America today. The earliest treatment of wildlife was as it related to forests and wastelands, and it is of interest that the earliest English forest law dealt more with wild animals than it did with trees. Among the Anglo-Saxons, hunting, gathering of fuel, use of wood, and forage for pigs were common uses of the forests.

Before the Norman Conquest it was the right of every man to hunt in his own fields, woods, or manor. But to all this, William the Conqueror, in the eleventh century, made a profound change. By usurping English common law he took over all forests as property of the king, together with the game and wildlife as parts thereof. And there were teeth in the rules of the Conquerors. To cause a stag to pant meant a year's loss of liberty. To kill it cost a freeman his freedom and a bondsman his life. William the First cut off the hands and put out the eyes of offenders. William the Second simplified the punishment by putting them to death.

In the year 1215, Magna Charta ameliorated the penalties, though the laws remained the same. Although a man could not afterward lose life or limb for killing a deer, he could be fined and imprisoned for a year and a day for it; he could not damage or cut down coverts, fell a tree, plow a meadow or dig up a plant without a heavy fine, unless licensed by the king to do so. It was not until 1482 that Henry IV first recognized the right of an in-

dividual to own a forest, which until then had been a royal monopoly. The sovereign right over game, however, persisted.

Subsequent changes occurred in forest management in England. Henry VIII in 1543 ordered planting of trees to reforest despoiled areas, and other improvements came along, although effective management of a constructive sort did not materialize until after the beginning of British colonization in America. As Shantz (1940) points out, our earliest pioneers left England 'during the period when forests still stood in the way of agricultural progress.' The same was true of wildlife in this country, for beasts of the forests were more to be feared than fostered.

For the purpose of our thesis, the main point is that wildlife in England remained the property of the crown, or at least has been so considered in the majority of legal decisions down to the present day. In the United States, we still must manage game under rules laid down by English kings, and game and fish remain the classic example of qualified property. They belong to the state, not as proprietor, but in its sovereign capacity for the benefit of all the people of the state. As Blackstone writes, in his *Commentaries on the Laws of England* (1783, vol. 4, pp. 415-16):

> . . . though the forest laws are now mitigated, and by degrees grown entirely obsolete, yet from this root has grown a bastard slip, known by the name of the game law, now arrived to and wantoning in its highest vigor; both founded upon the same unreasonable notions of permanent property in wild creatures; and both productive of the same tyranny to the commons: but with this difference; that the forest laws established only one mighty hunter throughout the land, the game laws have raised a little Nimrod in every manor.

So today in the United States a hunting or fishing license is purchased by the individual from the state. Federal authority with respect to game exists only by Act of Congress. The government can, through presidential proclamation, establish and manage refuges for wildlife, including protection of species thereon. It sets, each year, seasons and bag limits on migratory waterfowl,

regulates interstate and foreign commerce in wild animals, and controls importation of plumage, game, etc. It also enters into agreement with foreign powers for the protection of migratory birds, and protects as well the national symbol, the bald eagle. In Federal laws and regulations, however, the rights of the states are always recognized. Most fish and game laws remain in state rather than Federal hands. And, finally, the landowner upon whose land exists the habitat which nurtures and increases game has no more legal right to it than anyone who has purchased a license.

Early game laws grew gradually from hunting customs, many founded in tribal taboos regulating the reckless taking of the animals upon which the tribes in part depended. Our English predecessors leaned largely to restrictions, controls, and reservations for the chief means of preserving for royalty the hunting and fishing, which, as civilization developed, became less abundant. In his classical book on *Game Management*, Aldo Leopold (1933) sketches the history of the subject, pointing out that in England the first buck law was passed in 1406, the first closed season—for waterfowl and their eggs—was established about 1500, and the first bounty for control of predators, namely crows, choughs, and rooks, was paid about the same time. In 1536 Henry VIII had closed an area to shooting of pheasants, herons, and partridges, thus giving us the first English refuge, and about the same time the first game farm took form when the sovereign made payments for artificial raising of pheasants.

Very few of these early controls, the forerunners of our own game code, considered environmental manipulation, nor did subsequent rules and regulations prior to the days of settlement in Virginia and Massachusetts. It is not surprising, therefore, that in colonial days we spent most of our time destroying habitat. We had not brought with us, nor for centuries had we learned to consider, environmental improvement or land use as a wildlife management technique. The stage was not yet set.

II ⇝ THREE CENTURIES

Before Columbus

There is good reason to believe that the first American game animal to excite the admiration and wonder of white men was the turkey. These white men were not the Pilgrims, the Conquistadores, or Columbus and his crew. More than 200 years before Columbus set westward sail, a cathedral was built in Schleswig, northern Germany. Erected about 1280, original wall paintings of this church include, among the scenes from the life of Christ, floral designs and a frieze of small mammals and birds. One of the birds is a strutting turkey cock! The characteristic pose, spread tail, wattles, and beard leave no doubt of the bird's identity (Plate 2). The frieze contains eight reproductions of the fowl.

How did the artist in the German cathedral know about the turkey? The only reasonable answer is that the people of northern Europe, who were at that time trading with Greenland, had obtained turkeys from the Norsemen (Holand 1940). Greenland had been discovered in 986 by Eric the Red, and in 1003 Eric's son, Leif the Lucky, set foot upon the North American continent somewhere in New England. He built houses there, and the sagas tell us of the things the Norsemen saw. They saw rolling country, well timbered close to the beach which had white sand, in low

spots 'wheat,' grapevines, and grapes, and brooks full of fish.

For almost four hundred years—until 1362—the Norsemen visited America, and attempted to settle here. They explored the country, and some of them are now believed to have traveled from Hudson Bay to Douglas County, Minnsota, by way of the Nelson River, Lake Winnipeg and the Red River. They shipped timber to their homes in Greenland, and although their records do not say so, it is reasonable to suppose that the wild turkey was sent there too. From Greenland it could get to Europe by regular trade across the North Atlantic with Norway and the merchants of the Hanseatic League. One wonders what other birds and native animals the Norsemen knew, and what they thought of them.

Columbus and the Conquistadores

Although Columbus never touched the North American mainland, his voyage will always stand forth in the history of our country. He saw no animals native to the United States, but his diary is not devoid of references to wildlife. The weather on the famous voyage was in part delightful, like an Andalusian April, only the song of the nightingale wanting, he wrote. Before they had sighted land, the sailors of the three little ships had seen tropic birds, a dove, ducks, several other kinds of birds, and pelicans, some of which came aboard. On 7 October, less than a week before they landed, Columbus altered his course, knowing that the Portuguese had discovered most of the islands they possessed by attending to the flight of birds. Of the first landing, however, on what is now the island of San Salvador, or more probably Turk Island, in the West Indies, Columbus himself wrote that he 'saw no beasts in the island, nor any sort of animals except parrots.' The parrots were also among gifts the natives presented, along with balls of cotton thread, in exchange for trinkets Columbus gave them. About other islands he later wrote of birds

in great variety, honey, fruits, and lofty trees, but he does not seem to have observed native mammals, except the dog.

Other early voyagers reached our shores, but the journals of Johanno Caboto, Cortereal and Ponce de Leon, Verrazano and Gomez, Narvaez, Coronado, De Soto and others, do not tell us much of wildlife. What they do tell is largely incidental to our story, which rightly starts with permanent settlement and home-making on the Atlantic Coast three centuries ago. A word about the Spaniards in the Southwest, however, before the real story begins.

Among the Spanish Conquistadores who journeyed into the Southwest two full centuries before the colonists settled on the Atlantic Coast, the recorder of Coronado's expedition, Casteñada (Winship 1896), has left us notes on that country as it was in its virgin condition. Although most of the narrative deals with the country and the Indians, there are some observations on the vegetation and, here and there, notes on animal life. Of the country around the Seven Cities of Cibola—the Zuñi pueblo in west-central New Mexico—Casteñada wrote:

> This country is a valley between rocky mountains. They cultivate corn, which does not grow very high . . . There are large numbers of bears in this province, and lions, wild-cats, deer, and other.

This was in the year 1540. The next year Coronado himself, in a letter to the King of Spain, dated 20 October 1541, described Indian uses of buffalo skins and told of native dogs, 'which they load, which carry their tents and poles and belongings.'

The first buffalo observed by white men, however, had been observed even earlier. It was seen by Cortez in Montezuma's menagerie in Mexico City, in 1521 (Plate 2). Cabeza de Vaca, trying in 1530 to find his way westward to the fabulous cities about which he had been told earlier in Mexico, was apparently the first European to see the bison in its native range, probably somewhere in southern Texas.

The Colonists

Before the Pilgrims landed, notes on wildlife had been written in Captain John Smith's 1612 description of Virginia (Tyler 1907). Although the Captain's natural-history commentary was largely a layman's roster of plants and animals that had come to his attention, it is quaintly interesting. 'Of beasts,' he writes, 'the chief are Deare, nothing differing from ours. . . Their Squirrels some are neare as greate as our smallest sort of wilde rabbits. . . An Opassom hath an head like a Swine, and a taile like a Rat, and is of the bignes of a Cat. Under her belly, shee hath a bagge, wherein shee lodgeth, carrieth, and sucketh her young.' There are like comments on the flying squirrel, bear, beaver, wild cat, otter, fox, cottontail, many waterfowl, and numerous fish and sea foods, often cited by strange names or unfamiliar spellings. 'Martins, Powlecats, Weessels, and Minkes we know they have, because we had seen many of their skinnes, though very seldome any of them alive.'

We find the Captain writing of the raccoon and muskrat under peculiar names. 'There is a beast they call Aroughcun, much like a badger, but useth to live on trees as squirrels doe. . . Mussascus is a beast of the forme and nature of our water Rats, but many of them smell exceeding strongly of muske.' In another paragraph is the sentence: 'Pattridges there are little bigger than our Quailes, wild Turkies are as bigge as our tame.' Such early writings not only serve to list the species present; they indicate the origin of most of the common names of American animals—either Indian words or names of European animals similar to those observed here by the colonists.

The Pilgrims themselves, landing at Plymouth in 1620, were not in unknown land, although they suffered during the first winter as did the colonists farther south. White men had visited New England before the Pilgrims, and John Smith had penned a description of it and drawn a map. Some of the Indians had

learned English and had actually visited England. Such was Samoset's friend, Squanto, who lived with the Pilgrims, taught them how to raise corn, how to fertilize the soil with fish, how to stalk game and trap beaver. Plymouth's governor Bradford, in his historical account of the colony, wrote of duck for Christmas dinner and of how a man and his dog kept two wolves at bay.

American wildlife was part and parcel of the life of the early American. The debt we owe to it and to native plants is nowhere more delightfully celebrated than at the Thanksgiving spread. For the first Thanksgiving, in 1621, the Pilgrims ate deer, duck, sea food, fish, corn, and other native foods. Today Thanksgiving without these things would be no Thanksgiving at all. Turkey stuffed with oysters, chestnuts, or hazelnuts, white or sweet potatoes, lima beans, cranberry sauce, pumpkin pie, corn chowder or corn bread, salad with sweet peppers, tomatoes, Concord grapes, peanuts, pecans and other nuts—all these are indigenous to the New World and an inseparable part of the cultural heritage of America.

It is of interest to speculate on why the early colonists, in the midst of a primeval environment of abundance, suffered so much the first few years from lack of food, for they faced starvation often. It is sometimes stated that they were too 'civilized' to take adequate advantage of the provender of the woods, seashore, coves and streams which surrounded them. The English and Dutch commoners knew little of hunting and fishing—then the sport of rulers. Few if any of them had ever killed a wild animal or caught a fish. Living off the land was more foreign to them than it is to most urban dwellers of America today. The time of the pioneer was yet to be, and living in the wilderness was something Americans had not accomplished. Familiarity with fish and game, like the later encounter with forests, coal, iron, oil, strange soils and grassland, was something yet to be learned. With the help and example of the Indians and through perseverance and experience, the settlers did learn in time to adapt themselves to the new conditions and to living off the land.

Neither did the Spaniards, who visited the continent long before the English, seem to know how to hunt wild animals. The men of De Soto's expedition, landing in Flordia in 1539, brought not only horses to ride and fight upon, but also hogs, which they drove before them, for food. The narrator of the expedition, writing of one of their many difficult encounters, stated that the 'Indians did us very great injury, killing fifty-seven horses, more than three hundred hogs, and thirteen or fourteen men' (Bourne 1922).

Early Prohibitions

During these early years there was a great deal of game, and there was little in the way of custom or law regarding it. The earliest game regulations consisted primarily of legalizing the hunting that occurred. Hunting privileges were granted in New Netherlands by the Dutch West India Company in 1629. Provisions for the right of hunting were included in the Massachusetts Bay Colonial Ordinance of 1647 and the New Jersey Concessions of Agreements in 1678. A hundred years before the Revolutionary War, however, the idea that wild birds and mammals could be destroyed by promiscuous hunting entered the minds of thinking Americans. The solution then, and in fact until about the turn of the present century, was to perpetuate the game that existed by restricting the take and making it go as far as possible. The idea of treating game as a crop—to be managed and harvested—has taken shape only within the past twenty to thirty years.

The first American game 'laws' antedated the white man. The American aborigines had wildlife management measures of their own. Not only were there taboos regulating take, but more specific things were done. The Indians burned woodlands to make hunting easier and they undoubtedly applied other environmental practices. We know, for example, that they had established wildlife refuges of sorts. In his *Winning of the West*, Theodore Roosevelt (1894, vol. 1, p. 58) described many Indian tribes,

their customs, their wars, and their influence upon the pioneers. Of the Creek or Muscogee Indians, Roosevelt wrote:

> The bears had been exceedingly abundant at one time, so much so as to become one of the main props of the Creek larder, furnishing flesh, fat, and especially oil for cooking and other purposes; and so valued were they that they hit upon the novel plan of preserving them, exactly as Europeans preserve deer and pheasants. Each town put aside a great tract of land which was known as 'the beloved bear ground,' where the persimmons, haws, chestnuts, muscadines, and fox grapes abounded, and let the bears dwell there unmolested, except at certain seasons, when they were killed in large numbers.

Undoubtedly other tribes, like the Creeks, had their own kinds of wildlife refuges and hunting controls. These were not always effective, any more than many of our own regulations, for the Creeks lived in large towns which were shifted from time to time, 'as the game was totally killed off and the land exhausted by the crops.'

The first of the game laws of the United States is usually recognized to be that passed by Connecticut in 1677. It regulated seasons and prohibited the export of game, hides, and skins. By 1700 all of the original colonies, except Georgia, had established closed seasons to protect deer. William III, through Act of the Virginia Assembly in 1699, prohibited the killing of deer from January to July, the fine for violation being 500 pounds of tobacco. In 1730 Maryland followed suit; the fine was 400 pounds of tobacco. It also prevented hunting of deer by firelight that year. The doe was first protected by Virginia in 1738, and running deer with hounds (a practice long popular in England) was prohibited by New York in 1788.

Closed seasons on birds were first set by New York, and in 1708 that state protected the heath hen (now extinct), ruffed grouse, quail, and wild turkey; in 1791 it added the woodcock. Some of the colonists thought furbearers were also threatened, and Vermont in 1797 placed a closed season on muskrats, al-

though it was lifted four years later and re-established in 1812. Laws are of no avail without enforcement, of course, and in Massachusetts there were deer wardens as early as 1739, in New Hampshire two years later. Delaware in 1721 ruled against hunting without the landowner's permission. The first of our introduced game—the European or Hungarian partridge—was released in New Jersey in 1790. The earliest American book on shooting, *The Sportsman's Companion,* appeared anonymously in 1783.

Civilization's Impact

If the Colonial and Revolutionary periods in our history may be likened to the invasion and establishment of a beachhead along the Atlantic, then the 1800's saw the expansion and consolidation of our position across the Appalachians, the Great Plains, and the Rockies. This was the century of the nation's geographic growth—the century of exploitation. Eastern forests were cut, soils were eroded, the prairies were plowed, and the Great Plains grazed. The world had never seen anything quite like the impact this new nation of Americans made upon the natural resources of a large part of a great continent, and is not likely to experience it anywhere again. And what of wildlife then? As might be expected, the effect upon the homes of wild creatures was tremendous. A great change in the environment took place suddenly, and it was only the profound capacity for change which living things possess that preserved many of them for us today.

Huge herds of bison disappeared, and the pronghorn antelope dwindled to a handful. As species, these two large mammals were saved; others were not so fortunate. The Merriam elk disappeared about 1900. As every conservationist knows, the last surviving passenger pigeon died in the Cincinnati zoo, in 1914 (Plate 3). The species had not been seen in the wild since about 1906. Thus, years before the lone survivor, it was virtually destroyed, although it was once so abundant that in 1857 the Ohio legislature, report-

ing on a game bill, stated that 'the passenger pigeon needs no protection' and that 'no ordinary destruction can lessen them or be missed from the myriads that are yearly produced.' In the same state the last wild pigeon was killed only forty years later.

Less spectacular changes also took place, though they were as irrevocable. In the 1890's three races of grizzly bear—the Tejon, Texas, and Plains—disappeared, as did the giant mink of Maine and the Gull Island meadow mouse. Among birds the great auk, Labrador duck, and Guadalupe caracara disappeared before 1900, the Carolina paroquet sometime later. Although less is known of the exact time of their extirpation, it is quite likely that the last of the Adirondack cougar, Guadalupe rock wren, and Guadalupe towhee did not live to see the twentieth century. At any rate, none of these North American animals is known to be alive today.

Several other species have disappeared since 1900, or are so rare as to be virtually extinct. Among them are the Plains wolf, several races of grizzly bears, two bighorn sheep, and the Amargosa meadow mouse. The extinction of this mouse may be directly related to habitat change, for the marshes which it frequented in Inyo County, California, were seriously changed by frequent burning and pasturing. The last lone heath hen died, a solitary remnant of its kind, wandering in the shrubby dunes near Martha's Vineyard, Massachusetts, in 1935. The Cape Sable seaside sparrow survived until 1937. The Eskimo curlew is probably gone, no record of its existence having been made in recent years. Some of these animals were never abundant, others occurred in large numbers within the memory of many now living.

Some thirty mammals and half as many species of birds are today believed to be in real danger of extinction. In a story of endangered American wildlife (Beard *et al.* 1942) there are numbered among the threatened species the following: grizzly bear, bighorn sheep, woodland caribou (probably no longer in the United States), sea otter, marten, fisher, wolverine, manatee, wolf, mountain lion, California condor, trumpeter swan, prairie chicken,

Hudsonian godwit, Florida crane, roseate spoonbill, whooping crane, Everglade kite, swallow-tailed kite, white-tailed kite, and ivory-billed woodpecker.

More Protection

During the first half of the nineteenth century it was only reasonable to expect that protection would be given to more and more species of birds and mammals as their numbers dwindled and some became extinct. In 1818 Massachusetts placed a closed season on snipe; in 1820 New Jersey protected rabbits; in 1821 New Hampshire protected beaver, mink, and otter; in 1830 Maine protected the moose; in 1841 Pennsylvania protected squirrels; and in 1846 Rhode Island first prohibited spring shooting and protected ducks. During this period there became manifest an interest in non-game species, frequently neglected by the wildlife manager, who is too often concerned with game only. To Massachusetts goes the credit for the first protection, in 1818, of a non-game animal, the robin.

General protection to insectivorous birds was provided by both Connecticut and New Jersey in 1850. In that year the first predatory bird, the 'small owl,' probably the screech owl, was protected by New Jersey, and in 1861 Kentucky followed suit. The first hawk to receive protection was the osprey, upon which New York placed a closed season in 1886. Thus we began to express in legislation our first thinking about wildlife in general as opposed to game or animals of the chase. In the 'forties and 'fifties popular attention to wildlife supported the writings of Henry William Herbert, under the now-famous pseudonym of Frank Forester, sportsman extraordinary.

After 1850 increased legislation reflected not only greater concern about wildlife, but social complexities arising from an expanding population, and by 1890 all states had game laws of some sort. Restrictions on the hunting of diminishing species continued, and a few interesting ones bear citing. The prairie chicken was

protected by Wisconsin in 1851, elk by California in 1852, mountain sheep by Nevada in 1861, bison by Idaho in 1864, and caribou by Maine in 1870. Other things were taking shape, also. Although it was never enforced, the first license law, requiring a fee of ten dollars to shoot a deer, was passed in Suffolk County, New York, in 1867.

The first State Game Commissions were established in California and New Hampshire in 1878. The modern system of hunting controls was founded by providing resident and non-resident licenses by several states in 1895, although New Jersey in 1873 and Delaware in 1879 had previously required non-resident licenses. Guide licenses were established for Maine in 1897, for Wyoming in 1899. The earliest permits for scientific collecting were issued by Massachusetts in 1870, New York, 1886, and Pennsylvania, 1889. The westward sweep of empire is shown in wildlife laws as in much of our history, for the last of the states to adopt restrictive legislation were Arkansas, North Dakota, South Dakota, Utah, New Mexico, and Oregon.

About this time market hunting became big business, and wild ducks, prairie chickens, and many other wild animals were brought to the cities for sale in quantities that now seem unbelievable. A bag limit was set originally by Iowa in 1878, when the kill per day was limited to 25 prairie chickens, snipe, woodcock, quail, and ruffed grouse. Arkansas in 1875 prohibited hunting for market sale, although enforcement was difficult. Wisconsin prohibited the sale of protected game in 1887. It is well to remember that, although there were many laws about wildlife, 'putting teeth into them' did not in most instances occur for many years. Except for a few special wardens in some of the New England states, enforcement rested with ordinary police officials. New York as late as 1820 depended upon overseers of the poor to sue for game law violation. It was not until 1887 that salaried game wardens were employed—in Michigan, Minnesota, and Wisconsin.

In 1896 the first clear-cut definition of the right of the state over game was stated by Justice White, of the United States

Supreme Court, in a decision in the case of Geer *vs.* Connecticut (161 U.S. 519). Justice White wrote:

Undoubtedly this attribute of government to control the taking of animals *ferae naturae* which was thus recognized and enforced by the common law of England, was vested in the colonial governments, where not denied by their charters or in conflict with grants of royal prerogative. It is also certain that the power which the colonies thus possessed passed to the States with the separation from the mother country, and remains in them at the present day, in so far as its exercise may be not incompatible with, or restrained by, the rights conveyed to the federal government by the constitution.

It is this principle, plus police power—the right to legislate for the health, safety, and morality of its inhabitants—that provides the states with their authority over wildlife.

Conservation Forecast

It is of some moment to cast a glance at related measures taking shape during the latter part of the past century in America. In 1862 the Homestead Act awarded 160 acres of land free to any able-bodied citizen of good character who would live on the property and develop it. Other acts that tended to encourage occupation of the land, sometimes without regard for its inherent capacity for use, were passed during the closing years of the century. The Federal Bureau of Fisheries grew out of the Fish Commission, founded in 1871, and the following year the first of our national parks was established—Yellowstone. The first Forestry Agent was appointed in the U.S. Department of Agriculture in 1876. The Bureau of Forestry, created in 1898, finally became the Forest Service in 1905. In 1879 the U.S. Geological Survey was organized, and the Division of Irrigation took shape in the U.S. Department of the Interior in 1888. By 1891 Congress passed an Act giving the President power to withdraw forest lands from the public domain and set them aside as public forests.

The American Ornithologists' Union was organized in 1883. It was the first national scientific organization to take an active interest in wildlife conservation, and its Committee on the Protection of Birds in 1886 drafted a 'model law,' which was adopted by New York State the same year. The Union was instrumental in creating in the U.S. Department of Agriculture a Division of Economic Ornithology and Mammalogy, which in 1905 became the Bureau of Biological Survey. Today, combined with the Bureau of Fisheries, this Bureau forms the Fish and Wildlife Service of the Department of the Interior.

During the late 1800's private conservation organizations were also taking shape. Although the first public wildlife association, the New York Association for the Protection of Game, was organized in 1844, and is still in existence, it was not until thirty years later that the next society of the sort, the Massachusetts Fish and Game Protective Association, was formed. These, however, were the forerunners of many such organizations formed later throughout the country by private individuals interested in wildlife. The earliest sportsmen's magazines were *Forest and Stream*, first published in 1873, and *Field and Stream*, which appeared the following year. The editor of the former organized the first Audubon Society in 1886, and the National Association of Audubon Societies began in 1905. The first International Fish and Game Conference met in 1891 in New York and Detroit; the League of American Sportsmen was organized in 1898; and two years later the North American Fish and Game Protective Association was founded.

Refuges, Predator Control, and More Laws

By this time a potent idea in game management was taking form. If wildlife could not be saved by dictating the time and place at which people could hunt and by controlling the number of animals to be killed, in short, by restrictions, perhaps it could be saved by setting aside inviolate areas of land upon which wild-

life could be preserved. From these areas, it was argued, wildlife might move out and populate other areas and provide hunting for all. Thus the sanctuary or refuge idea was given emphasis. On Federal lands, wildlife was first protected in Yellowstone National Park in 1894. The first state wildlife refuge was established in California in 1870, and the first Federal wildlife refuge—Pelican Island off the coast of Florida—was created in 1903. The first National Game Reservation—in the Wichita Mountains of south-central Oklahoma—was set up in 1905. The present system of migratory waterfowl refuges did not get under way until 1929, as mentioned below.

About this time the Federal Government entered into another aspect of wildlife management. In 1915 the first appropriation was made for the control of predatory animals. This appropriation was motivated largely by demands from western cattle raisers for aid in controlling wolves. Predator control—the idea that by killing the enemies of game the game can be preserved—is not a new idea, of course. The bounty system, as an attempt to reduce unwanted predators, is an old one, the very first bounty in this country having been paid by the Massachusetts Bay Company in 1630 for destruction of the timber wolf. Bounties are still paid in many parts of the United States on numerous species, and millions of dollars are annually spent to reduce predatory species and other wild creatures thought to be detrimental.

Since 1900 laws have been passed at such a great rate that we shall allude to only a few significant items. From 1901 to 1910, 1324 game laws were enacted in the United States, an average of 133 per year (Palmer 1912). Among them were many new restrictions, a few of which may be cited as signs of the times. Use of automatic shotguns was prohibited, first by Pennsylvania in 1907. Gun silencers were outlawed in 1909 by Maine, North Dakota, and Washington. A license to photograph big game animals in winter was required by Wyoming in 1905, and payment for damages by deer was authorized by Vermont in 1902. It was during the early 1900's that impetus was given to the idea that

game animals could be made available to hunters by raising them in captivity and releasing them in the field. Game farms resulted and began to appear, as in Illinois, Indiana, and Pennsylvania, about 1905, with Illinois usually credited with the first.

National Interest

Until the present century, legislation respecting wildlife was the result of state action, as might be expected inasmuch as the state, in its sovereign capacity, owns the wild animals within its boundary. The states exercise all powers over wildlife not expressly forbidden them by the United States Constitution, and so exert the chief statutory control. Nevertheless, the Federal Government has certain constitutional powers under which it can conduct activities relating to conservation. These are power to: (1) make treaties, (2) regulate interstate and foreign commerce, (3) administer the territory and other property of the United States, and (4) raise money by taxation which is to be spent for the general welfare. It will be noted that activities of the Federal Government with respect specifically to wildlife are related in some way to one of these four broad authorities.

Under the treaty-making power, fur seal fisheries of the Pacific Northwest and Alaskan coasts are now protected and regulated, as are the North Atlantic fisheries and Northern Pacific halibut fisheries. The same Federal power has been exercised with respect to migratory birds. Under the commerce clause, interstate transport and importation of various wild birds are prohibited. Under the third power of the Federal Government—administration of territory and property—Congress now administers Alaskan wildlife through an Alaskan Game Commission, set up in 1925. In the absence of laws to the contrary, the governments of Hawaii, Porto Rico, and the Philippine Islands are vested with authority over wildlife. In this connection it is interesting to learn that the District of Columbia is a wild animal refuge by Act of Congress, 14 July 1932, prohibiting the killing of wild animals there. Insular

dependencies—Canal Zone, Virgin Islands, Guam, and Samoa—are ruled by governors who have authority to make regulations, including those that deal with wildlife conservation.

On 'other property of the United States' authority is not always clearly defined. On Indian Reservations hunting by Indians, who are wards of the government, is usually not subject to state law. In National Parks and Refuges protection usually prevails. National Forests and some other Federal lands may be closed to hunting and fishing regardless of state law. It is also possible for the government to destroy game on lands under the administration of Federal agencies during seasons closed by the state, if the game is destroying public property, as in the case of deer destroying trees in the Kaibab National Forest of Arizona. On Federal lands not closed to hunting or fishing by Act of Congress or government regulation, however, state game seasons apply.

The final type of Federal power—contained in the general welfare clause—has been exercised primarily through assistance to states in various types of wildlife-conservation activities. Assistance is provided through Federal agencies co-operating with the states and by grants-in-aid of one sort or another. Types of activities are wildlife research, fish and game propagation, rodent and predatory animal control, and land acquisition and development. Various aspects of these Federal powers, the form and expression they assume, are touched upon in the remaining portions of this chapter and elsewhere in the book.

To resume our historical summary, the first Federal wildlife legislation came into being with the passage of the Lacey Act in 1900. This Act prohibited the importation of any foreign wild bird or mammal, and was motivated in large part by concern over the spread of the English sparrow, which had been introduced in 1850. The Act furthermore declared dead game animals to be subject to the operation of the same game laws that applied to animals that had been killed in the state. It also prohibited transportation from any state of birds or mammals that it was illegal to import, and likewise prohibited the transport of dead

bodies or parts of such animals. The sale of feathers, quills, plumes, and other parts of wild birds for millinery purposes was therefore checked; it was later controlled by the Tariff Act of 1913. Some years later, in 1926, a somewhat comparable Federal law regulated interstate transportation of black bass.

Conservation Takes Shape

In 1902 the Federal Reclamation Act saw the entrance of the Federal Government into land-use programs involving individual land operators. It was a movement in keeping with the general policy of the United States to 'get the land directly into the hands of small owners who shall also be cultivators of the soil.' The Act was a corollary of the Homestead Act, for if the government disposed of land to settlers, it was also obligated to assist them to obtain water upon it to grow crops. Arguments pro and con have revolved about reclamation down to the present day, including the effects of drainage and irrigation upon wildlife habitats.

We still have to achieve a desirable correlation between various aspects of land use and a unified approach to the problems it presents. It was in May 1908 that President Theodore Roosevelt called the famous White House Conference of the Governors, attended by the President, several cabinet members, governors of the States and Territories, and many others. At this meeting the idea crystallized that our natural resources could not only be preserved, they could be managed, and thus intelligently used. It was the first time in the nation's history that the governors, thirty-four of whom personally attended, were assembled to consider a great national question, and it was the beginning of the modern conservation movement. The governors endorsed a series of strong resolutions and shortly afterward the President appointed the National Conservation Commission to inventory the natural resources of the country. Within a year and a half, forty-one State Conservation Commissions were formed and a half-hundred other commissions were set up representing national

organizations. Another result was the First North American Conservation Conference held in Washington, 18 February 1909.

The establishment of the National Park Service in 1917, to administer the National Parks, was an event of importance to wildlife, for the parks serve as refuges where fishing but no hunting is permitted. Important with respect to Federal influence was the passage of the Weeks-McLean Migratory-Bird Act in 1913, which declared migratory birds within 'the custody and protection of the United States.' The constitutionality of this Act was challenged by the states and never settled. It was replaced in 1918 by the Migratory-Bird Treaty Act, providing for an agreement between the United States and Canada, which gave protection to migratory game, migratory insectivorous birds, and migratory non-game birds that inhabit Canada during part or all of the year. Mention should be made at this point of the Weeks Act, passed in 1911, which authorized Federal purchase of forests at headwaters of navigable streams and Federal-state co-operation in forest-fire control.

The Izaak Walton League of America was organized in 1922, and ever since it has been a potent influence for the benefit of wildlife, particularly fish, and the improvement of streams. Numerous other independent groups have since formed to add their voices to the demand for conservation.

Although the administration of wildlife resources in many states long remained largely a political matter, as it is to an extent today, public opinion gradually began to make itself felt. By 1920 several states, notably Pennsylvania, New York, and Michigan, were developing regulations, establishing policies, and employing conservation personnel with considerable freedom from political influence. Another great step in wildlife conservation was taken when attempts were made at environmental improvement. This was done first in the National Forests where management measures were tried experimentally on public hunting grounds. Pennsylvania was the first state to follow suit and in 1917 it tried out

the first system of artificial food patches, which are still used, especially in farm game programs.

During the years of World War I conservation lagged. In efforts to produce more crops, 'clean' farming was encouraged, forests were promiscuously cut, the Dust Bowl was born of indiscriminate plowing of the High Plains, and there was pollution of streams by increased industrial use, sewage, and erosion silt. All this tended to have adverse effects upon wildlife by undesirable modification of environmental conditions. Furthermore, as Bennitt (1941) has suggested, there was not yet any public realization of the importance of the idea that scientific methods could be applied to wildlife conservation, or recognition of the concept that the conservation of wildlife is an integral part of the conservation of all natural resources. Even today we are only beginning to obtain general consciousness of these concepts. One of the disastrous effects of a war such as that the world has just experienced is the irreplaceable drain upon natural resources.

The Stage Is Set

During the past twenty years the most important events affecting wildlife have, for the most part, been measures directed more at conservation generally than at wildlife in particular. A number of Congressional Acts influenced wildlife and its welfare. In 1924 the Clark-McNary Act provided, among other things, for Federal-state co-operative effort to supply nursery stock to landowners and to extend efforts in forestry education. Four years later further extension work and research facilities in forestry were provided by the McNary-Sweeney Act. In 1937 the Norris-Doxey Act, known as the Co-operative Farm Forestry Act, provided for further nursery production, reforestation, woodland management, co-operative marketing, and research. In 1940 the President was empowered, by executive order, to set aside refuges for fish and game in the National Forests. The latter is made possible through the Joseph T. Robinson Forest Refuge Act.

In 1933 there came into existence, to last until World War II, the Civilian Conservation Corps, an organization that contributed considerably to constructive conservation work. That year also saw the formation of the Soil Erosion Service which, in 1935, through the Soil Conservation Act, became the Soil Conservation Service, representing commitment of the Federal Government to a national program of soil and moisture conservation, including the conservation of agricultural wildlife.

A change in the nation's attitude toward homesteading, the public domain, and land use was expressed in the Taylor Grazing Act of 1934, which prohibited further settlement on 80 million acres of the remaining public domain and authorized the control of grazing on public grazing lands. In 1937 the states began passing soil-conservation districts laws, resulting in closer Federal, state, and private co-ordination of activities directed at erosion control and improved land use on private and public lands. These are but a few of the Federal acts relating to use of land that have an effect upon environment, and thus upon wildlife. They illustrate the extent of national concern with conservation.

It may be well to mention a few of the outstanding conservation events of the past two decades that deal more specifically with wildlife, even though they may not affect wildlife itself more profoundly than conservation developments that deal with the land. In 1929 annual Congressional appropriations of a million dollars for ten years for the acquisition and maintenance of refuges for migratory birds—inviolate wildlife sanctuaries—were authorized by the passage of the Migratory-Bird Conservation (Norbeck-Andresen Sanctuary) Act. An Act requiring the purchase of a stamp by every hunter of migratory waterfowl, the proceeds to go toward better refuges, was passed in 1934. The same year the Co-ordination Act was passed in an attempt to obtain consideration for wildlife in public works such as water impoundments.

Today there are special committees on wildlife conservation in both the United States Senate and the United States House

of Representatives. In 1935 the American Wildlife Institute was founded. Supported primarily by arms and ammunition manufacturers, the Institute, recently reorganized as the Wildlife Management Institute, is one of the most active agencies of its kind. It sponsors the annual North American Wildlife Conference—top meeting in its field. This meeting succeeds the American Game Conference, held first in 1915. The Institute subsidizes the publication of outstanding wildlife books, and it aids in the support of research units in ten states, with the Fish and Wildlife Service and the state colleges co-operating. Some time later, in 1936, the National Wildlife Federation was formed. It is an organization of local and state sportsmen and others interested in wildlife. The Federation is influential in many wildlife affairs, and annually publishes a sheet of beautiful stamps depicting native plants and animals, proceeds from the sale of which go to further its work. Wildlife management finally reached professional stature in 1937, when the Wildlife Society was organized. A technical group, the Society publishes the quarterly *Journal of Wildlife Management.*

A treaty between the United States and Mexico for the protection of migratory birds was signed in 1937, and the same year saw the passage of the Pittman-Robertson Act. This Act, officially known as the Federal Aid to Wildlife Restoration Act, provides for a 10 per cent excise tax on sporting arms and ammunition and gives Congress authority to appropriate proceeds to the states for assistance in purchase of lands for wildlife, development of lands for wildlife, and wildlife surveys and research. The states match Federal funds on a 25 to 75 per cent basis.

It is of interest that our national symbol, the bald eagle, was left from the long list of protected species until 1940, when it became a Federal offense to shoot the bird. In 1940 the Inter-American Convention on Nature Protection and Wildlife Preservation, held in Washington, called for establishment and extension of national parks and comparable natural areas throughout the hemisphere. Protection of wildlife, especially that which migrates between countries, was a prime objective of the Conven-

tion. Now signed by seventeen American republics, this pact is further evidence of growing international interest in the preservation of our wildlife as well as other natural resources.

This historical sketch is far from complete. It presents selected representative events in an attempt to show developmental trends. From it an idea may be gleaned of what we have thought and done about wildlife conservation, and, for that matter, the conservation of other natural resources. The earliest rules and regulations were composed almost entirely of controls, restrictions, and prohibitions. Then came the idea that special areas—preserves, refuges, sanctuaries—would serve to save wildlife for us. The same concept was held for forests, parks, and even Indians. There followed the notion that releasing game raised in captivity could provide plenty of wildlife. The idea that intensive campaigns against predators could rescue desired wildlife also took hold. Finally there crept into our thinking the concept of habitat improvement and the idea that wildlife depends largely on the kind of living conditions provided for it.

Through all of this history there is also reflected an increasing interest in wildlife on the part of the general public. This is shown by the formation of national organizations concerned with numerous aspects of wildlife conservation and by varied Federal and state legislation pertaining to wildlife and its welfare. As a result of the influence of wildlife technicians, we have begun also to think of wildlife as a crop, and to accept the idea that it can be managed and harvested according to stated rules. The next step seems to be to attain widespread environmental improvement by means of what we do with the land as we take from it the food, fiber, and other things necessary to maintain a living.

III ⋙ FIRST THE LAND

EXPERIENCE teaches us that the most likely way to produce wildlife is to attend first to the land, and that we should approach the conservation of wildlife from the standpoint of land use. The management of cattle and sheep on the western range is as much the manipulation of vegetation as it is the handling of livestock. Forest management involves consideration of sites, preservation of the soil through proper cutting practices, and other measures directed at the land itself, as well as attention to the trees. It is not surprising that in growing ordinary tilled crops the farmer looks to the selection of appropriate location and soil type, proper cultivation and fertilizing of the land, as well as to good seed and careful harvest.

The history of our concern with wildlife shows that we have paid far less attention to the land as a factor than we have when we were raising cultivated crops, livestock, or woodland products. It shows, instead, a preponderant interest in the species of wild birds and mammals themselves, their protection and propagation, their classification and habits, their migration, food, and enemies, their diseases, reproductive capacity, and interrelationships. We have elaborate administrative and law-enforcement set-ups, as well as various educational vehicles for controlling and informing the people who hunt and fish and otherwise have an interest in wildlife. It is impossible, of course, to manage wildlife without adequate knowledge of the animals we wish to encourage or without

efficient administration of Federal and state agencies concerned with the many regulatory and legislative aspects of wildlife management. The teaching of facts concerning all aspects of the subject is likewise highly important.

In the United States three hundred years have given us unparalleled knowledge, administrative organization, and educational facilities, and we are now beginning to appreciate other factors in wildlife management that can give substance and meaning to existing efforts directed at the preservation and increase of desirable native fish, birds, and mammals. These factors are the relation of wildlife to use of the land and the importance of the land operator in the production of the crop.

The Refuge

The most important attempt to solve wildlife problems by means of land use, though certainly not the ultimate solution, was the development of the refuge idea in America. There were private wildlife preserves in Colonial days, such as the deer parks of Maryland, Virginia, and North Carolina, some established in the seventeenth century. During the Revolutionary period most of them ceased to exist. By 1850 they began to reappear and have persisted in increasing numbers ever since. There is a long history of state-refuge management, beginning with California in 1870, until today there is about three times as much land in state wildlife refuges as in the more publicized Federal refuge. It was thirty-three years after California set the pace that the next state refuge was established, in Indiana in 1903. Then the number increased more rapidly—Pennsylvania in 1905, Alabama in 1907, Massachusetts in 1908, Idaho in 1909, and Louisiana in 1911.

As already noted, the first Federal wildlife refuge was established in 1903. At first refuges were small and were for colony-nesting species of birds such as pelicans, terns, and gulls. In 1908, a year that saw thirty-six refuges created, sizable areas were set

up for the first time and two sanctuaries were created for migratory waterfowl in Oregon—Lower Klamath and Malheur Lake refuges. Management of the refuges, it soon became apparent, required something more than proclaiming them sanctuaries. Diversion of water for irrigation threatened the Lake Malheur area. Klamath Lake was drained for agricultural use, only to expose alkali flats. Other factors combined to make it difficult for the refuges to accomplish their objectives.

The year 1908 saw the establishment of wildlife refuges in Alaska. The following year the first big-game refuge was founded under Federal administration—more than 12,000 acres on the Flathead Indian Reservation for a national bison range. In 1924 Congress for the first time enacted a bill specifically appropriating funds for the purchase of a fish and wildlife refuge—the Mississippi River bottomlands from northern Illinois to southern Minnesota. In 1928 Congress appropriated another sizable sum to establish the Bear River Migratory Bird Refuge, where Bear River flows into the shallow marshy margin of Salt Lake, Utah. The following year the Norbeck-Andresen Act, already referred to, finally set the stage for the development of a comprehensive system of migratory waterfowl refuges.

The land acreage in the continental United States devoted to Federal refuges increased from slightly over a half-million acres in 1928 to more than nine and a half million acres in 1941. Between 1933 and 1936 there was an outstanding increase of more than four million acres in the amount of land devoted to wildlife refuges, resulting in part from a special appropriation of six million dollars for the migratory waterfowl restoration program. That year also saw the establishment of the Hart Mountain Antelope Range in Oregon and the Desert Game Range for mountain sheep in southern Nevada.

As of 15 March 1942, according to the Chief of the Fish and Wildlife Service (Gabrielson 1943), there were 272 Federal wildlife refuges in the United States and Alaska, embracing 17,643,915

acres, nearly half of which were in Alaska. Their type, number, and acreage were as follows:

Type	*Number*	*Acreage*
Migratory waterfowl	184	2,962,025
General wildlife	25	3,973,754
Colonial non-game bird	46	104,149
Big game	16	10,601,364
Wildlife research	1	2,623

Until recently, the refuge or sanctuary idea was the only land-use idea in wildlife management to which we as a nation, through Federal laws and appropriations, had given any great measure of support. Refuges, however, fall short of providing us with abundant wildlife, primarily because even now they comprise less than 1 per cent of the total land area of the country. The refuge is a thing apart, and the refuge concept probably delayed acceptance of the idea that wildlife could be produced as an integral part of land-use programs.

There are, of course, some good reasons for refuges. They may serve to protect vanishing species and, more importantly, their habitats. Even in such cases, however, the type of threat to the continued existence of the species may influence the success of the refuge. If it is hunting that threatens the species, protection in other parts of its range may be as valuable as the sanctuary provided for it within the refuge area. If disease or some other natural factor is an element in the decrease of a species, the protection afforded by establishment of a refuge may not be enough to save it.

There is also the claim that refuges provide an adequate breeding stock of wildlife that presumably moves out of the refuge area to populate other areas. We still lack biological proof, however, that this sort of thing happens to any appreciable extent, although far too little is known of the movements of animals, especially wanderings or migrations that are non-seasonal in nature.

There is some question about the value of refuge areas for species so reduced in numbers that their existence is in jeopardy, for such species may have lost the vitality or 'biologic potential' necessary to perpetuate them under any circumstances. Many biologists believe that, once the passenger pigeon was reduced in numbers below a certain population, the species was doomed, because the pigeons then seemed to have lost the desire to nest. Nesting habits and behavior of the passenger pigeon were apparently associated with large concentrations of the birds.

By far the greatest number of Federal refuges have been established to protect breeding grounds of migratory waterfowl. The refuges, together with hunting controls, have played a part in the conservation of American waterfowl. The importance of their role may well be overemphasized, because they were for the most part established during a period when the country was experiencing a low in a long-trend rainfall cycle. The subsequent increase in ducks and geese may have been a natural one resulting in part from habitat improvement through climatic variation. At any rate, it is now generally conceded that the many ponds, reservoirs, and other water impoundments created throughout the Great Plains and along other migratory waterfowl flyways in connection with land-management programs are as important to the welfare and increase of ducks and geese as large refuge lakes. The former, in fact, present more 'edge' for nesting and feeding, and tend to break up concentrations of birds, which favor spread of waterfowl diseases.

The chief disadvantage of the refuge system as a solution to wildlife problems is based upon its land-use aspects. It is literally impossible to solve conservation problems by land purchase. Already nearly 18 million acres are in national wildlife refuges. There are 50 million acres in state refuges, although some of this acreage may not be state-owned. There are 55 million acres in Federal Indian lands, 13 million in National Parks, 155 million in National Forests, 7 million in State Forests. There are 20

million acres in highways and roads, another 10 million in cities and towns, and, since the war and certainly in the future world, a great acreage in airfields. About 27 per cent of America's land surface is government-owned—Federal, state, county, and city. The way to conservation is not through government ownership of land; it is through good land management by whoever owns it.

In addition to refuges as a kind of land-use approach to wildlife management, it should not be forgotten that the National Forests and National Parks represent a type of land use in which wildlife is given consideration. In the forests the manipulation of wild animals is considered a necessary and integral part of forest management, and in the parks all birds and mammals are protected in natural conditions as little changed as possible. Management of forests and parks is often believed to be less important to wildlife than treatment of lands specifically set aside for wildlife. Such management in the long run, however, may be of equal or possibly greater significance to wildlife than use of refuge areas, because it is an attempt to produce yields of wildlife as complements of land use directed primarily at other ends.

We can reasonably asume that most species of wild animals will have to continue to live on land devoted first of all to uses other than wildlife production. In other words, wildlife production for the most part must be a by-product of other land uses. The idea that we can 'restore' wildlife is untenable—we cannot go back to 'nature's management,' if we mean by that to restore nature's primeval conditions, except in a few isolated protected land areas. Unless programs of wildlife restoration are programs of habitat improvement favoring species adapted to prevailing uses of the land, they cannot permanently endure.

Land-Use Programs

It has only been within the past decade and a half that any loud voices have been heard calling for production of wildlife

through land-use programs. That wildlife management and land use go hand in hand is an idea only beginning to gain full support. There is still considerable emphasis on older concepts, as one might expect. For instance, the Report of the President's Committee on Wild-life Restoration (Beck *et al.* 1934), published by the Government Printing Office in 1934, 'after full consideration,' made nine recommendations, five of which dealt with the purchase of lands to be dedicated as wildlife sanctuaries. Three other recommendations had to do respectively with technical studies, maintenance, and improvement of the areas to be purchased. The last was a suggestion for a Federal administrative set-up to execute 'this program of national wild-life restoration and future conservation.' It said nothing of the larger problems of general land management.

Another example of how we began to grope toward more workable concepts in conservation is shown in the title of the report of the U.S. Senate Special Committee on Conservation of Wildlife Resources, which appeared in 1937. It is *Wildlife and the Land: A Story of Regeneration*, but the ninety-page publication, set in small, crowded government type, deals almost entirely (with the exception of a few introductory remarks) with the establishment of Federal wildlife refuges. The types of environmental improvement stressed are largely artificial, including constructed fish shelters, brush heaps for upland game, and nesting boxes for wood ducks.

But by this time other ideas were stirring. They were expressed not only by the 'old-line' wildlife managers but by those who were engaged in land-use programs. The American Game Policy, prepared by a committee headed by Aldo Leopold and adopted by the Seventeenth American Game Conference in 1930, was the first important declaration that game should be considered a crop of the land, and that 'only the landholder can practice management efficiently.' In 1931 Leopold pointed out that 'if the cover needed for watershed conservation were restored to the drainage

channels and hillsides of the North Central region, the upland game problem would be half solved.' The following year Herbert Stoddard, who had been learning how to manage land for practical quail production, stated in his classic book on the bobwhite:

> Curiously erosion, which is a serious enemy of the farmer over much of the Piedmont, is indirectly becoming an increasingly important ally of the quail in its fight for existence. To check erosion as gullies and 'washes' develop, brushy thickets are allowed to grow up around them, and these offer ideal cover for quail. If additional areas also are planted around the thickets with the erosion-resisting Japan clover (*Lespedeza*), both food supply and shelter will be afforded for the game birds. Such measures may be profitably adopted wherever destructive erosion starts. . . Terracing the land may be made to favor the quail if cover is permitted to grow on the terraces.

Although we now know more about plant species and practices appropriate to this end, Stoddard's fundamental idea is still as modern as any.

The idea of looking to land-use practices for wildlife welfare soon began to pick up emphasis. Howard M. Wight, in his suggestions for pheasant management in Michigan, emphasized in 1933 the importance of revegetating eroded gullies, and the same year Leopold treated the subject in his excellent book on *Game Management*. The year 1934 stands out as an unusual one in the development of the concept of 'land-management biology.' That year saw publication of a Farmer's Bulletin by Grange and McAtee entitled *Improving the Farm Environment for Wild Life*, which stressed the value of thickets and other types of wildlife cover for checking erosion. The first statement before Congress, pointing out the importance of including consideration of wildlife in programs of erosion control and land use, was made in 1934 by J. N. Darling, then Chief of the Bureau of Biological Survey, before the House of Representatives Special Committee on the Conservation of Wildlife. That year also Ernest G. Holt presented

a paper before the Twentieth American Game Conference on *Erosion Control and Game Development*, a paper which presaged much of the wildlife work actually accomplished in ensuing years by farmers and ranchers as part of a national program aimed at erosion control and agricultural adjustments. Before the same Game Conference an agricultural economist, C. F. Clayton, presented a significant paper entitled *Land-Use Planning and the Game Crop*. Although the paper deals largely with land acquisition, modern thinking is evident in comments on land classification and use. Clayton stated, in part:

> But no individual or organization can long deal with any aspect of conservation without realizing the close interrelation between that aspect and every other. The pursuit of our problems of conservation along these important, but, after all, restricted lines, has led us ultimately to the realization that a balanced economic and social life must provide for the forest as well as for habitations for man. . . The theme of the argument is that the whole pattern of conservation must be visualized, in order for each part to be fitted into its appropriate place. The preservation of our wildlife resources must be fitted into that pattern, if a proper balance between the artificial and natural environment, essential to the good life, is to be maintained.

Since 1934 a great deal has been done to point the way toward integration of wildlife management with land management.

Concepts of land classification and land use as they relate to wildlife have been treated in some detail by the author (Graham 1943; 1944). Methods of land management beneficial to wildlife compose the remaining chapters of this book, with the gist of the approach twofold. First, there are parcels of land suited better to wildlife than to the production of any other crop. Second, on all kinds of land there are numerous land-use practices that can be rendered valuable to wildlife by appropriate modification.

Among the parcels of land adapted best to the production of wildlife are gullies and other badly eroded areas, odd spots such

as rocky outcrops, escarpments and highly alkaline areas, spoil-banks of drainage and irrigation ditches, overturned earth of strip-mined areas, the gravel left by gold dredges in the Far West, the banks of streams, borders of eroding fields, highway cuts and fills, and wet areas unsuited to tilled crops, pasture, or woodlands. Many of these sites, such as gullies, are small and may be only a fraction of an acre in size. Others may be acres in extent, as strip-mined areas and marshes. These 'wildlife lands' all have one attribute in common. They are physically unadapted to use other than wildlife production, and it is, in the long run, a waste of time, labor, and materials to try to produce on them cultivated crops, livestock, or wood products. If they are to be managed at all, their most efficient use is for the production of some wild crop, either wild animals or, in some instances, wild plants such as fruit-producing and honey-yielding species, or special plants such as peppermint and herbs.

The extent of these areas is appreciable. The total amount of wildlife land in the continental United States is believed to be about 100,000,000 acres. Careful estimates, however, are available only for land in farms (Bennett 1942; Davison 1942a). It may be well for comparison to recall that slightly more than half the land in the United States is land in farms. There are no less than 33 million acres of land on American farms and ranches adapted best to wildlife use. The management of these wildlife lands on farms and ranches will not require the withdrawal of a single acre from private ownership, nor will it reduce the yields of other crops or farm products. It demands primarily a knowledge of what the land is good for, intelligent suggestions for its use, and application of the recommended treatment. Even if such areas are only recognized and protected from fire and grazing, they will be improved for wildlife, although careful evaluation has shown that more than half of the 33 million acres could be improved by some kind of treatment. Table 1 shows acreages needing the application of some of the land-use practices of special value to

wildlife, according to a recent survey of conservation needs by the Soil Conservation Service.

TABLE 1. SOME LAND-USE PRACTICES OF WILDLIFE VALUE AND ACREAGES NEEDING TREATMENT ON FARMS AND RANCHES

PRACTICE	ACRES
Marsh Management	6,500,000
Pond Management	1,000,000
Streambank Management (vegetative treatment only)	1,000,000
Field Borders	3,000,000
Management of Odd Areas	6,000,000
Spoilbank Management (including strip-mined areas)	250,000

In addition to types of land suited best to wildlife use, there are special land-management practices particularly adaptable to cropland, pasture, and woodland that are of value to wildlife. Careful forestry methods, such as selective cutting, are helpful to wildlife. It is likewise true that the stocking of the western range in reasonable balance with carrying capacity maintains a stand of native grasses beneficial to prairie chicken, sage hen, antelope, and other rangeland wildlife. Stock-water developments on rangeland provide water for wild animals also. Even on cropland, good management pays wildlife dividends. Windbreaks and hedges help wildlife, and we know that strip cropping to prevent soil erosion increases the numbers of ground-nesting birds. The more we learn of good land management, it seems, the more we know of good wildlife management (Plate 4).

Reference is often made throughout this work to proper land use and sound land management. It is therefore necessary to state briefly what is meant by good management. Good land use requires first of all a careful classification of land based upon natural characteristics—a classification that will serve as a basis for the most intensive use consistent with preservation of the land as a permanent productive resource. A usable scheme must designate the physical capacity of various kinds of land to produce over a long period of time under stated conditions of use,

and provide operators with a basis for actual practice on specific parcels or units of land. There are various systems of land classification. One now gaining prominence through use by hundreds of thousands of farmers and ranchers undertaking soil- and water-conservation work throughout the country is known as a Land Capability Classification. It was developed by the Soil Conservation Service and references are made to it in discussion of the practices in following chapters.

Along with a guide to determining how land can be used best, good land management involves the application of all technical knowledge pertinent to such management. There must be brought to bear on land-use problems, in an integrated and effective way, numerous sciences such as agronomy, biology, engineering, forestry, soil science, range management, and appropriate related fields of knowledge. The successful land manager—farmer or technician—must be able to synthesize from each of these fields something of the principles basic to each of them. There must result a plan of action for each farm, ranch, or operating unit of land, in which each parcel is first properly classified as to use, and then adequately treated in accordance with the best technical skill known to be applicable to it. It is through such approach to land management that the biologist—the wildlife manager—gains an appropriate position in land-use programs. And through such approach wildlife management takes its rightful place as a phase of land management.

How It Can Be Done

Granting that the approach to wildlife management expressed in this book is reasonable, the skeptical may still demand how it is to be done. Leopold, in writing a review of a state wildlife report (1937), ends by asking:

. . . aside from the merits of the report, where does it lead us on the question of how to get conservation? To the same old dead

end: Wildlife can be built up by building up the environment, but who will do it? Public agencies want to, but can't, private landowners can, but do not want to.

Landowners and operators do a great deal for wildlife when they establish wildlife-improvement measures that are applied first of all because they are good land-management practices.

It is not reasonable to expect a land operator to continue to plant a food-patch mixture of annual crop plants—corn, sorghum, millet, etc.—on good ground, where it is more profitable to grow cultivated crops upon which the whole economy of the farm is based. It is reasonable, however, to expect a farmer to establish and maintain on the eroding margin between the crop field and woodlot, where cultivated crops do not grow well anyway, a permanent cover of perennial plants. Vegetation of this sort not only provides food and cover for wildlife but also reduces erosion, checks desiccating winds blowing into the woodlot, prevents spread of trees into the crop field, and furnishes a turn-row for teams. The failure is not that the landowner does not want to do anything for wildlife, but rather that he does not know what to do and has not been furnished practical suggestions that can be integrated with the normal work he undertakes on the unit of land he operates.

If there seems to be any doubt of the fundamental value of land management to wildlife welfare, it must be dispelled by recourse to studies by wildlife managers themselves. A review of the life histories of game birds and mammals reveals one conclusion, almost without regard to the species studied. That is, that we must look to the treatment of the land if the species is to survive and increase.

In a study of the life history of the Gambel quail in Arizona (Gorsuch 1934), recommendations include proper stocking of the range with livestock in keeping with its carrying capacity to prevent overgrazing; deferred and rotation grazing; fencing of areas of brush for protection of food and cover plants; and the

end of 'clean' farming. The prairie chicken of Illinois has recently been investigated (Yeatter 1943), with the conclusion that even 'these birds can maintain themselves in good numbers in close contact with certain types of agriculture.' They are still making a strong stand in the areas where redtop—a hay grass—is grown. Farming practices that favor prairie chickens are found to be moderate grazing, prevention of grassland fires, and use of late-harvested hay crops such as clover, lespedeza, or mixed grasses and legumes.

In southern Michigan a study of the ring-necked pheasant (Wight 1933) indicated that desirable management calls for hedges and fencerow vegetation, protection of woodlots from grazing, development of roadside vegetation, and planting of eroding gullies to food and cover plants. A study of the Hungarian partridge in the Great Lakes region (Yeatter 1934) includes the statement that 'game management is entirely compatible with good farm management,' and discusses specific practices, many the same as those believed useful to pheasants. Pointing to contour furrows in pastures, hedges, planting of gullies, and the retirement of steep slopes from cultivation, Lehmann (1937) states that 'habitat improvement for quail coordinates closely with soil conservation. . . Anything that builds soil ordinarily helps vegetation that constitutes food and cover for quail.'

In analyzing the catch of furbearers—muskrat, mink, raccoon, skunk, opossum, foxes, weasels—in the highly agricultural State of Illinois, it was concluded that if 'every gully scar . . . were planted to protecting vegetation, if every woodlot were properly managed by removal of stock and if every stream were kept reasonably clean of silt, sewage, and commercial waste, then populations of furbearers, and game as well, would increase' (Mohr 1943). This in a state where the average annual catch of furbearers is almost a million pelts, worth better than a dollar apiece! In a study of the wild turkey in Virginia (Mosby and Handley 1943), it was found that good forest operations comprised the most practical turkey management. Most of the turkey habitat in

Virginia is in private ownership, and selected forest cutting, some planting of poor woods, and protection from fire and grazing are among the significant practices recommended.

It is of some moment that wildlife depends not alone upon the cover, food, and water that an environment affords. There seems to be a direct relation between wildlife welfare and the quality of the soil. Studies of various game species have indicated, for example, that there is a closer correlation between weight of cottontail rabbits and variations in soil types than there is between rabbit weight and climatic type. There seems to be a ratio between average weight of raccoons and soil fertility, and comparable correlations have been suggested for other species, for example, the wild turkey.

It cannot be concluded that the richer the soil the more abundant the animal life it will support, for there are many influences to habitat beside soil type, especially under conditions of human use. Nevertheless, there is enough parallel in soil fertility and wildlife yield to remind us once more that with wildlife, as with other crops, the land is of first consequence. In a recent review of this matter, built around experience in Missouri, Arthur H. Denney (1944) states:

After three years of careful study, we reached the conclusion that the influence of climate, food, cover, water and the protection of the breeding stock alone, would not explain the irregular distribution of some species. Because these superficial environmental factors were inadequate to explain the status of some species, a new basis for game range classification was sought. It was found in soil types, and for the last two years since that concept was adopted the study and the practical application of its findings have made great progress.

One of the findings of the Missouri studies was that individual weight and total number of both cottontails and raccoons were greater on soils of high fertility than on soils inherently less fertile. The relation was more direct between weight of animal—rabbits varied from an average of 2.1 to 2.8 pounds, raccoons from

11.98 to 18.54 pounds—and soil type than it was between number of animals and soil type. Use of the land was the factor believed to influence animal numbers, which reached a high point on medium fertile soils. There were slightly fewer animals on the most fertile soils that were also the most heavily used.

The dependence of wildlife upon the soil has been stated by others. In an article on big game animals, Rush (1940) wrote that 'soil and soil crops are the *capital stock*' with which wildlife managers deal and that 'wildlife is the *interest* on this capital.' Another student, A. E. Moss (1939), as a result of considering the upland game and land-use practices in Connecticut, stated that 'the success of pheasant stocking . . . is very closely related to the average productivity of the soil. Increase of pheasants on the less productive soils can be brought about only by land-management practices that will improve food and other habitat conditions.'

We like to think of game as something wild and characteristic of untrammeled wilderness. When we hunt or fish we like to reach a place no one else has found. Yet no one knows better than the experienced hunter or fisherman that today in the United States there is no such place. All our land is owned privately or by the public, and it is all being used in one way or another. If wildlife is to thrive on the land, it will do so because what is done by those who use the land permits it.

The proof that those who privately manage land will apply the practices discussed in this book is evidenced by what has actually been done. This is well expressed by the work of farmers and ranchers in soil-conservation districts throughout the country. In 48 states, land operators in more than 1700 districts embracing 900 million acres of land, as a part of their regular operations, are incorporating pond and marsh management, field-border vegetation and treatment of odd areas, planting of spoilbanks and gullies, establishment of hedges and windbreaks, and other land-use practices of value to wildlife. These soil-conservation districts are composed of farmers and ranchers who by petition and a

majority vote have been granted the right by the state to function as a legal subdivision of the state. The district's affairs are guided by a group of supervisors or directors—all local farmers—and the land-use program to be followed is carefully laid down in written form by the members of the district, who have at their disposal technical assistance from various state and Federal agencies.

Thus local groups have plans of action, based upon the most careful analysis of land conditions at hand. The work done includes the application of many different practices designed for proper management of cultivated land. It embraces the best use of pasture, range, and woodland without damage to the soil. It also includes appropriate measures for fish and wildlife management. What is vastly more important, plans are being translated into action on the land. As a result, wildlife benefits not so much because someone has a plan for wildlife management, but because a concerted approach to better management of all land gives wildlife its rightful place and integrates the conservation of all land resources into a single workable program. This objective is most important. Only through an integrated program can we reasonably expect to conserve most of our natural resources, of which wildlife is one.

IV ⇛ MARSHES AND SWAMPS

One of the outstanding conflicts between those who want land preserved for wildlife and those who think it ought to be used for other purposes is centered about wet lands, particularly their drainage. A consideration of such lands is especially appropriate as we begin the discussion of land-use methods beneficial to wildlife. A review of what has happened to some of our marshlands and swamps points not only to mistakes that were made by draining lands that should not have been drained; it also shows that drainage has its proper place in a comprehensive scheme of land use. Above all, it emphasizes the necessity of analyzing and classifying the land for its most appropriate use before any operations are undertaken.

The controversy between those who want wet lands for wildlife and those who prefer to use them for other purposes is an old one. In England a Commission of Sewers was set up by the Crown prior to 1500, with its primary concern the draining of the fens—marshy areas of Lincolnshire and some other English counties. Under Henry VIII improvements were promoted, and by the early part of the next century considerable drainage was in progress. Many fenmen who depended upon the marshes for a living defended them for their value as cattle pasture and made much of the fact that they hunted wild geese and ducks there. The fens, they further contended, offered employment to many thousand cottagers who gathered there 'reeds, fodder, thacks,

turves, flaggs, hassocks, segg, fleggweed for fleggeren collars, mattweeds for churches, chambers, beddes and many other fen commodytyes of greate use both in town and countreye.'

In addition, it was pointed out, 'The fens preserved in their present property, afford great plenty and variety of fish and fowl, which here have their seminaries and nurseries; which will be destroyed on draining thereof; so that none shall be had, but at excessive prices.' Opposing these interests—nearly 400 years ago as today—were those who claimed that a tame sheep was better than a well-grown eel, and that good grass and grain were more to be desired than sedge. The result, as evidenced centuries later, seemed to be the growing of tilled crops and plentiful fish and fowl as well (Darby 1940). Some of the land was drained for cultivation; some of it was too wet for crops and remained good for wildlife.

To appreciate much of our own attitude toward wet lands it is helpful to glimpse something of early policies and practices. With settlement and subsequent expansion to the South and West, our boundaries soon embraced thousands upon thousands of acres of land much too wet to be cultivated. Like other wilderness areas, the swamp was a menace to progress—a hindrance to settlement. There were open coastal marshes, timbered floodplains and deltas, upland peat bogs, and soggy river headlands. National interest took definite shape in the Swamp Lands Act of 1849, when Congress granted to Louisiana 'the whole of those swamps or overflowed lands, which may be, or are, found unfit for cultivation.' The year following, the larger portions of swamp and overflow land were ceded to the several states. It was felt that the Federal Government was not in a position to treat these lands, and that in their existing condition they were worthless.

The national Act provided that proceeds from sale of such lands should be applied toward reclaiming them. As it turned out, the proceeds were in most instances put to all sorts of uses except that stipulated. Benefits were considered to be mosquito control in malarial areas, subsequent cultivation, and finally enhance-

ment in value and readier sale of adjoining government property. In these considerations we can now, in retrospect, see the genesis of many of the difficulties still besetting us in attempting the most profitable management of wet areas. These difficulties revolve around the mistaken idea that permanent marshlands need mosquito control, that once drained they must surely be good for raising tilled crops, and lastly, almost complete neglect of the fact that such lands might be most permanently productive when used for muskrats, or for the preservation of marsh birds of unique interest, or for some other wildlife purpose.

Swamp-land grants were made to Minnesota, Oregon, California, Iowa, Missouri, Alabama, Arkansas, Florida, Indiana, Illinois, Ohio, Michigan, Wisconsin, and Mississippi. About 65,000,000 acres of wet lands were patented to these states. Florida, Louisiana, and Arkansas obtained three fifths of the acreage. The bulk of the remainder was located in the Great Lakes region. There were not only many conflicts and irregularities involved in claims, sale, and title regarding the lands involved, but there were difficulties with identification and delineation of the lands themselves. It was found that many of the government surveys of swamp lands, on which the grants were based, had been made in dry seasons, and therefore included only those swamps that were irreclaimable. Amendments to the original Act provided for inclusion of inundated areas, and other changes were necessitated. The states frequently claimed lands only occasionally flooded, and many complications arose (Hibbard 1939). Gradually it became clear that the states were not reclaiming the land as intended, and since 1900 there has been more and more emphasis upon national activity, with Federal agencies playing a part in drainage and irrigation work.

For the Best Use

Within recent years various governmental bureaus that deal with the management of land have given more and more atten-

tion to the use of water, not only providing it for arid lands, but draining it from wet areas potentially capable of supporting cultivated crops and pasture. The work is now undertaken in most instances only after careful surveys are conducted to determine the capabilities of the land, and consideration is given to all possible uses, including wood products, wildlife, water-table stabilization, and recreation. Use in relation to contiguous areas is also considered. Thus we are learning that wet lands must be carefully studied before they are disturbed, and that in many instances it may in the long run be most desirable not to disturb them at all.

If marsh and swamp lands are useful in undisturbed form, it will be well to state briefly the nature of their value. First, and from the standpoint of human welfare, probably the most important value is their effect upon the maintenance of water levels. It is common knowledge among country people that there are far fewer springs than at the time of the early settlers. Wells must be sunk deeper now. Springs and wells are dependent upon ground water, that is, water that has penetrated from the surface through the soil into undersurface strata of gravel or porous rock. It is surprising how much influence this ground water has on stream flow. Of the total flow of streams, even in shallow soils, up to half may be from ground water. In deep glacial soils, such as occur in some of the Lake States, almost the entire flow of streams may be from water stored in the ground. Upland marshes also have value as reservoirs for storing water during periods of heavy rainfall, thus contributing a share to flood control.

The production of timber takes an important place among the values of swamp lands. Coastal and inland southern swamps have produced highly valuable crops of cypress, sweet gum, and other timber trees. Their use for wildlife, such as muskrats, ranks high among the merits of marshes. Migratory waterfowl refuges, havens such as the Florida Everglades for unusual birds, the marshland margins of Great Salt Lake, and numerous other wet wildernesses add much to the aesthetic and recreational elements of a varied land.

Recent careful soil surveys and land-use analyses by the Soil Conservation Service reveal some interesting facts. There are 127 million acres of wet lands in the United States. About 31 million acres of these have been farmed at some time in the past, but there is too much water on the surface, or too much water in the soil, for satisfactory farm operations. The land is potentially good agriculturally, however, and it would be wise and probably profitable some day to drain it.

The remaining 96 million acres of wet lands have never been cleared for farming. Some day part of this may be cropland. Most of it—78 million acres of it—is unsuited to crop production because of the inherent quality of the soil and soil conditions. This land should never be drained. It is not suitable for farming according to present standards. Most of it serves best when it is left in its natural state. Yet it is not wasteland. Some of it can be grazed; much of it supports high-grade cypress. It can provide preserves for wildlife, or, if only slightly modified, as when marshes are improved for production of muskrats, it can be made to yield an appropriate wildlife crop. Experience teaches us that we must look to the potentiality of the land before changes are made. Restoration for wildlife has been the ultimate recourse for many areas mistakenly drained. In Michigan the Seney Marsh, in Wisconsin the Horicon, in North Dakota the Lower Souris River floodplain, in Oregon Lake Malheur and the Blitzen River Valley, Lake Mattamuskeet in North Carolina, and Mud and Thief Lakes in Minnesota are examples of wet areas that are now being restored to something like their original condition because they are more valuable as wildlife habitats than for any other use.

One of the first of the important waterfowl reservations placed under the supervision of the Federal Government was Lower Klamath National Wildlife Refuge, containing more than 80,000 acres, part of which were in Oregon and part in California. Originally one of the greatest nurseries for ducks, geese, and marsh birds in the western states, this vast shallow lake was bordered

with miles of marshy shore and harbored hundreds of small tule-covered islands. Of this area Stanley G. Jewett (1943) writes:

At the time the area was made a refuge in 1908 literally clouds of birds of many species darkened the sky; the thunder of their wings was like the roar of distant surf, and their voices drowned out all other sounds. These vast summer flocks, moreover, were greatly increased each fall when the legions of ducks, geese, swans, and cranes from northern nesting grounds stopped on their journey to their winter homes in the valleys of California, and again in spring on their return northward. It was during the nesting season in early summer that the birds could be seen and studied at their best.

It was on Lower Klamath Lake that market hunters had carried on their slaughter of ducks and geese by the wagonload for city markets, and that plume hunters had ruthlessly killed equally large numbers of terns, grebes, and other birds unfortunate enough to possess plumage desired by the millinery trade. The lake also was the mecca for fur trappers, who gathered a rich harvest of mink, otter, and other fine furs each winter. There, too, early ornithologists eager to learn more about the birds of the West found an outdoor laboratory worthy of their most studious efforts.

At that time the waters of the lake were deep enough for small power boats, and water trips were made from the city of Klamath Falls down the Klamath River into Lower Klamath Lake. People came to see the vast colonies of grebes and the geese, pelicans, herons, gulls, and terns that nested in the marsh by the tens of thousands. But the growing demand for agricultural lands brought a change. A gate was built across the channel that flowed into Lower Klamath Lake, and within four years the lake had dried up and peat fires had started, burning to a depth of six feet and more. The result was 'a vast alkaline, ashy desert from which clouds of choking dust arose, often obscuring the sun.' Part of the lake bed was then cultivated with very poor results. Several large livestock ranches along the old shores were rendered worthless because of the change in water level. Land well suited to the production of wildlife thus became totally unproductive.

As a result of land settlement and speculation, drainage of many inland swamps was undertaken. Federal laws encouraged the procedure and the states often supported and entered into construction of drainage works. Kenney and McAtee (1938) write of such work in northern Minnesota:

Much of the land reclaimed was never settled, and other land was abandoned because it was not productive enough to bear the cost of reclaiming it. County governments in some cases have been unable to retire drainage bonds coming due. By 1934 the State of Minnesota had spent $4,000,000 in aiding distressed districts. Other losses also resulted. According to a report by the Minnesota State Planning Board: 'The disastrous fires in the Red Lake territory in 1910, 1918, and 1931 can be traced directly to the desiccation of these normally wet areas.'

In the wildlife field there is great to-do about past mistakes. This is particularly true, somehow, of drainage. We remind ourselves that similar mistakes should not be made again. Unfortunately, conditions seldom repeat themselves, whatever may be said of history. Mistakes are avoided largely by a careful approach to problems as they arise. Today we can deal analytically with problems of wet land—we know how to prevent its ill-advised use. Furthermore, we need not necessarily lament forever the drainage that has been done in the past. For those who claim paradise for old marshlands, the modern land-management biologist has a counter claim. If a mistake has been made, the drained marsh, flooded again, may be a better place than ever for wild creatures.

A study of three drainage projects in Louisiana seems to support this view. One of the areas was a brackish marsh. Portions of it are cultivated now, but it is generally recognized as an economic failure. It is also a very poor place for wildlife. The other two areas—one a brackish, one a fresh-water marsh—were drained for cultivation, later abandoned. Although they have had less than ten years in which to recover, these areas are now excellent places for fish, furbearers, and waterfowl. It has led the investigators

(Penfound and Schneidau 1945) to write that their '. . . observations indicate that drained lands which have been reflooded not only become excellent wildlife areas, but that they usually produce a greater variety and a greater quantity of wildlife than the original marsh or swamp which was drained.'

It is easy now to lament the passing of great and famous marshes. Some portions of them were mistakenly drained, to be later abandoned or reflooded in attempts to re-create marsh conditions. Others offered more to mankind when they were freed of the waters upon them, and are now producing tilled crops (Plate 5). As with almost every other kind of natural area in the United States, the greatest pity perhaps is the fact that we have not preserved, here and there, stretches of representative marsh undisturbed by man. Such areas could serve as ecological checks, to indicate what might be expected from wet lands in the way of yields of the products for which such lands are naturally best fitted. As points of reference they could guide the practical management of comparable wet areas for which men are trying to find productive use.

If most land is ultimately to be put to the use for which it is best adapted, it must be acknowledged that some wet lands will serve best for crops or livestock. Much of it, as just explained, should never be drained. Decisions in regard to which land is to be drained, which not, need to be based upon accepted standards of evaluation. Such standards are available, and it is of paramount importance that the biologist and the land manager understand these guides and agree upon their application. The standards are to be found in systems of land classification, to which the student of wildlife management must assiduously attend (Nat. Conf. Land Class. 1940; Norton 1940; Hockensmith and Steele 1943; Graham 1943; 1944). Without a thorough understanding and working knowledge of land classification, it is scarcely possible for the biologist to work with those who deal with the management of wet lands. Nor will he be in a position to defend their use for the purposes for which many of them are inherently

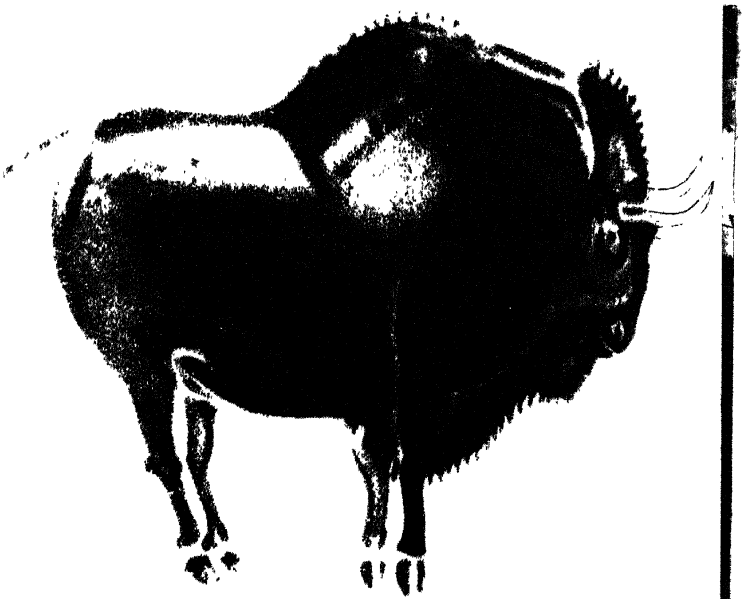


PLATE 1: TOP. A European cave mural of an extinct bison demonstrates man's earliest interest in wildlife (from Osborn 1923).
BOTTOM. The American bison decorates a National capital bridge.

PLATE 2: TOP. The American turkey from the frieze of a north German church built in the year 1280 (from Holand 1940).
BOTTOM. The first printed likeness of the American bison was published in a Spanish book in 1553 (from Garretson 1938).

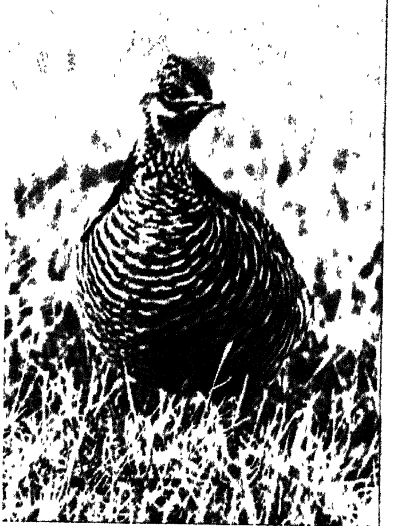


PLATE 3: TOP. A legal take of ducks in 1913 reminds us we once thought wildlife was limitless.

BOTTOM. The last heath hen (right) died in Massachusetts, 1935, and the last passenger pigeon in the Cincinnati zoo, 1914.

PLATE 4: TOP. Badly used land provides neither wildlife nor other products of the soil. BOTTOM. People prosper and wildlife thrives on well-attended land.

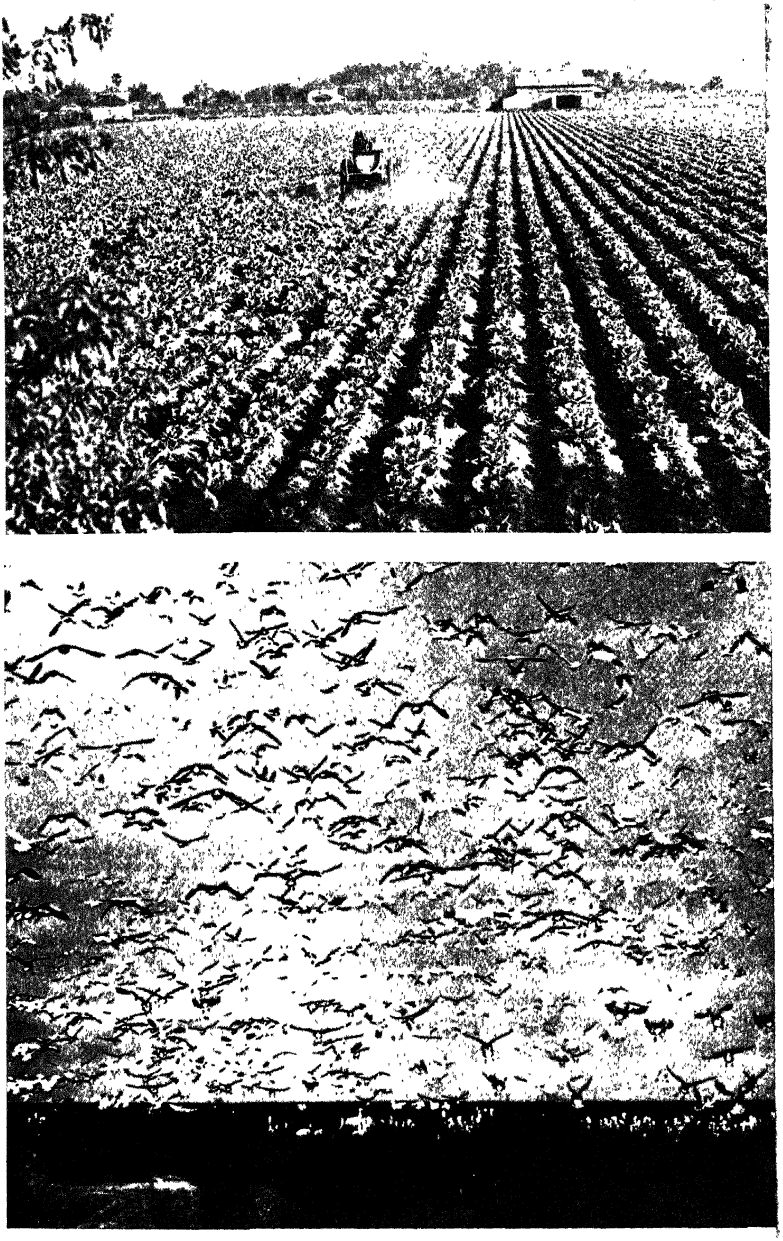


PLATE 5: TOP. Some wet lands are best used when drained for crops such as Florida cabbage. BOTTOM. Other wet lands are most wisely used when devoted to wildlife.

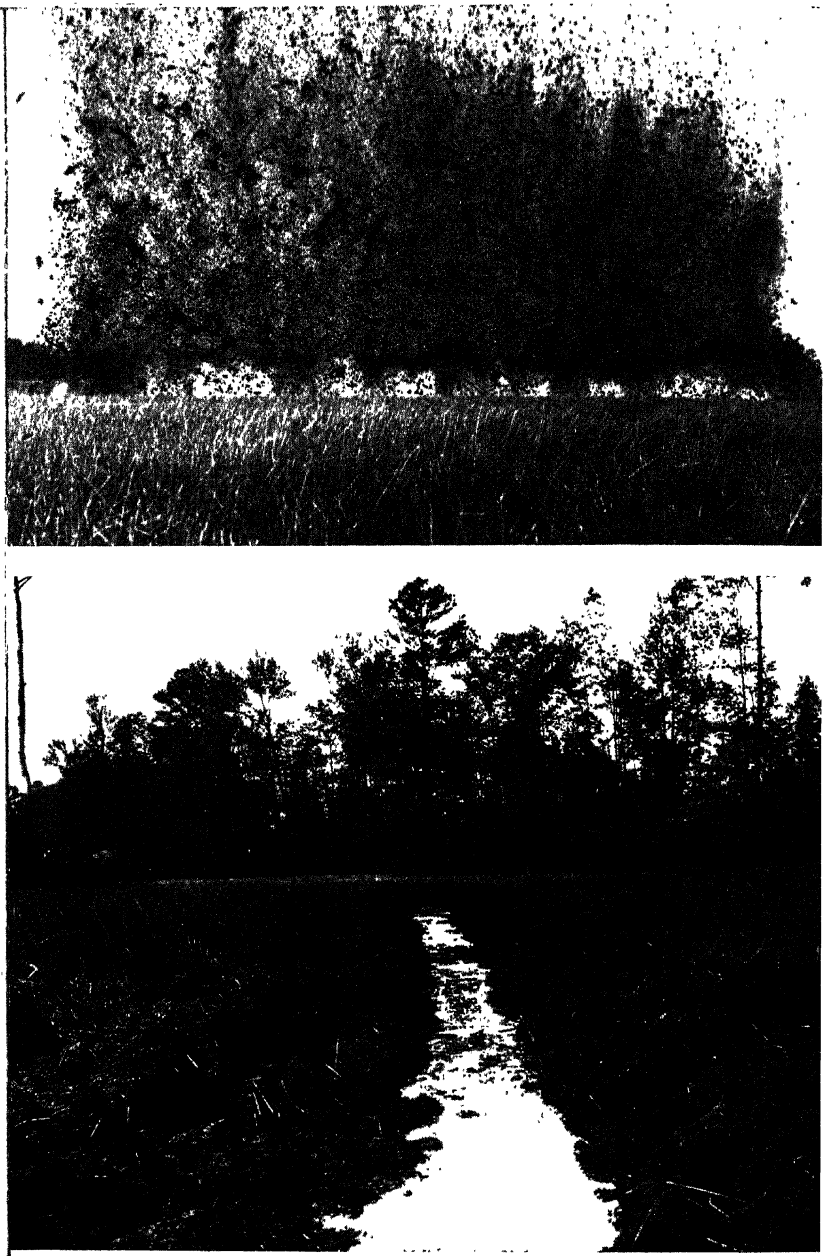


PLATE 6: TOP. Blasting ditches is a practice employed to make marshes yield more muskrats.

BOTTOM. A neat new ditch inexpensively blasted in a Virginia coastal marsh.

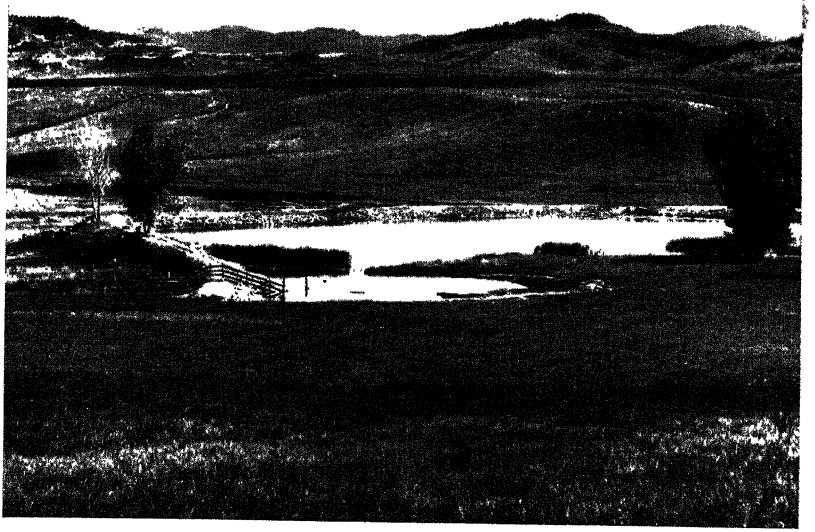


PLATE 7: TOP. A pond has many land-use values and provides a place for fish, waterfowl, and furbearers.

BOTTOM. Canada geese (left) and a mallard duck find nesting sites on the margins of farm ponds.

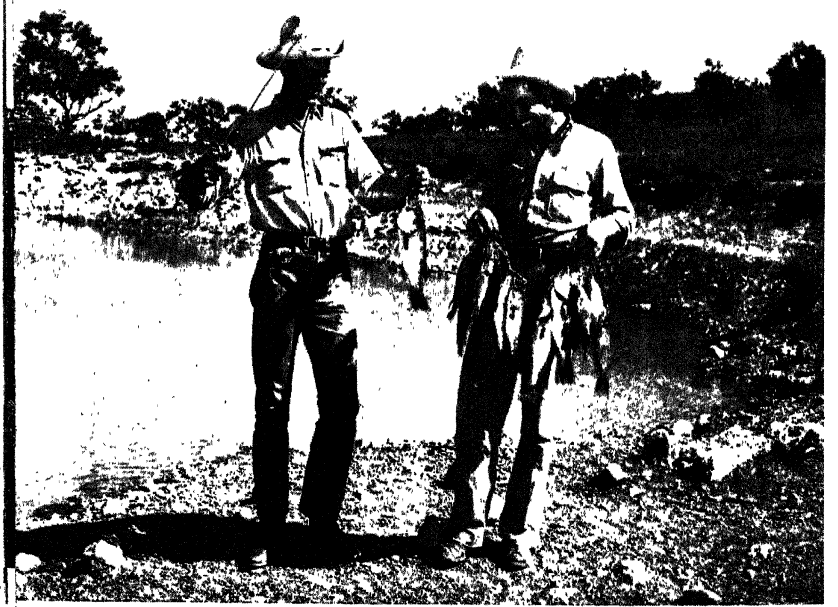


PLATE 8: TOP. Man-induced erosion destroys habitat by siltation of lakes, ponds, and streams.

BOTTOM. If ponds are free from silt they can produce bass and bluegill like these from a 2-year-old Texas pond.

suited—the preservation and production of wild plants and animals that are dependent upon them.

In this connection it is worth noting that bottomlands, on which the soil and soil conditions permit growth of cultivated crops, are often profitably drained as a land-conversion measure. In many sections of the United States it was easier to clear hills for crops than to clear and drain flat floodplains. But most steep slopes are not adapted to tilled crops, and they erode seriously. The solution often is to bring cultivation down from the hills to the bottomlands, and convert the slopes to permanent vegetation of pasture grasses or trees. Such a change is in the interest of a permanent agriculture. It means a shift also in wildlife populations because it involves a change in habitat, but it does not mean destruction or irreparable damage either to wildlife or to habitat.

Mosquito Control

We cannot avoid reference at this point to a bitter controversy that has waged between those who have advocated mosquito extermination, especially along Atlantic Coast States, and those who have opposed it. Wildlife interests contended that coastal salt marshes were very valuable habitats for migratory waterfowl and other wildlife. Others claimed mosquitoes were a nuisance and carriers of malaria. Marshes are often classified as permanent, intermittent, and temporary. In a permanent marsh, where water is always present, mosquitoes are normally controlled by a great number of natural enemies. Mosquitoes are devoured by numerous insects, including the back swimmer, whirligig beetle, water boatman, water strider, water tiger, nymphs of dragon flies, and larvae of other insects. Some birds and bats eat them, as do tadpoles and salamanders. Even some plants consume them, for the inflated sacs of the submerged bladder-wort capture larvae of all but anopheline mosquitoes.

These enemies of mosquitoes are insignificant, however, compared with certain fish. In a recent book on the control of mos-

quitoes in New Jersey, Headlee (1945) states well the case for ecological control of mosquitoes, as follows:

The common killifish, otherwise known as the 'mud-fish,' 'mud-dabbler,' 'mummichog,' and 'salt water minnow' (*Fundulus hetoroclitus macrolepidatus* Walbaum), is perhaps more effective than any other fish as a salt marsh mosquito larvae destroyer. . . This species is abundant everywhere to the extreme limits of tide water. They are equally at home in salt or fresh water, the clearest water or the muddiest pool or ditch. They are not even averse to filthy sewage water, collecting in vast numbers at the mouths of sewers at low tide. They will be found in the most insignificant and shallowest depressions on the flats or marshes, in ditches filled with reeds, spatterdocks or masses of submerged plants, and in muddy holes devoid of plants or other shelter. They will push through places where there is hardly enough water to cover them. . .

Briefly stated, the control of the salt marsh mosquito is a matter of so ditching the marsh that none of the water which remains upon it will stagnate, but all will rise and fall with the tide and be everywhere penetrated by large numbers of killifish. The only exception to this rule is the permanent salt marsh pool which, being constantly stocked with killifish, turns off no mosquitoes. While it is true that low-lying sections of the marsh widely open to the tide, which are covered by practically every high tide, do not breed mosquitoes, it is also true that such areas under a series of low tides will sometimes turn off considerable.

Intermittent marshes, such as high-lying or shut-in meadows over which the tide rarely sweeps, are mosquito-breeding places. They are probably best managed by so damming or pooling them that they become in essence permanent marsh areas. They are then of value to waterfowl and muskrats. Temporary marshes that dry up now and then should be eliminated if they hold water five days. They are in a class with old cans and other receptacles likely to collect and hold water artificially, and they make ideal mosquito-breeding areas.

There is evidence that it is feasible to control mosquitoes in tidal marshes and at the same time maintain a habitat suitable to

migratory waterfowl. The Massachusetts Department of Conservation in 1936 started to make the 1300-acre Duxbury Marsh near Boston once again attractive to birds. At one time the marsh had been a great gunning ground, but in 1931 it had been drained to eliminate mosquitoes. The restoration of the marsh included as its first objective maintenance of an environment favorable to killifish, which would destroy the mosquitoes. So outlets were dammed with peaty sod remaining from the drainage operations, in such fashion that the marsh was kept free of surface pools, although the water level was not altered enough to change the vegetation. Pot holes were cleared out, burning was practiced, and other management measures were undertaken to improve the marsh as a wildlife habitat. A marked increase in wildlife resulted, and in a technical report Bradbury (1938) concluded that the work at Duxbury 'proved that by avoiding drastic drainage, mosquito control work on our tide marshes can be carried on successfully without causing injury to migratory bird habitat.'

From inland marshes the story is much the same. In a recent report on some of the malaria control and wildlife conservation work of the Tennessee Valley Authority (Wiebe and Hess 1944), it was stated that experiences '. . . during the past five years on the relations between malaria control and wildlife conservation on impounded waters indicate that many of the conflicts between these two interests are apparent rather than real; actually the two fields have several mutual interests.' It is then pointed out that several malarial control operations are of benefit to wildlife, for example, reservoir site preparation, marginal drainage, shoreline maintenance, control of aquatic plants like lotus, and encouragement of biological controls, such as stocking of fish predacious on mosquito larvae.

Marshes for Muskrats

One of the important products of economic value to be derived from the management of wet lands is the muskrat pelt. Using

marsh management as an example of wildlife land use, let us see what it entails. It is now recognized that the number of muskrats is in direct proportion to the amount of edge present, the edge being largely that where water and marshy land meet. The highest income per unit of land is along ditches, such as those used to drain land in Ohio and Illinois.

The practices useful in managing marshlands for muskrats are the following:

1. *Fencing.* Necessary in places where cattle trample the marsh, eat the vegetation, and disturb environmental conditions generally. Where grazing is permitted, numbers of livestock should be limited so that food supplies and burrows of muskrats are not damaged.
2. *Ditching.* Should be in accordance with sound biological as well as engineering standards to insure efficient use of time, labor, materials, and equipment, and with adequate attention to effects on the marsh and adjoining lands.
3. *Control of Water Levels.* Should be in accordance with standards comparable to those for ditching, because ditching that drains a marsh or floods it is undesirable. Without structures that may be necessary to maintain the water in the ditches, the latter are useless.
4. *Seeding and Planting.* Should be done (a) when desirable natural vegetation cannot be expected to develop within a reasonable length of time and (b) to establish especially desired plant species. Not much experience is at hand to guide us in choosing species of plants to use for revegetating marshes. Reed canary grass and cattail have been established in some places for the purpose.
5. *Controlled Burning.* Burning should be in accordance with proper safeguards to prevent damage from fire. It should be undertaken only when the desired vegetation will not be killed by the kind of fire used.
6. *Harvesting.* Should be within limits of biological recommendations that are also in accordance with state and Federal laws and regulations.

In addition to the management measures listed above, it is important to protect the marsh from burning, except when the fire

is controlled and for a purpose. Accidental fires should be put out, and it is well to establish fire breaks by ditching or by controlled burning at suitable locations (Allan 1944).

Of the practical measures for improving marshes, perhaps ditching is the most important. It improves conditions not only for muskrats, but for minks and raccoons, two other very valuable furbearers. It should be emphasized that the desired ditching does not drain the marsh, or flood it. If it does either it is unsuccessful. The object is to create travel lanes for the mammals without changing the vegetation. Even a slight change in mean water level will almost always cause a change in marsh vegetation, so nicely are the plants of marshlands adjusted to environment. Ditching opens the marsh to muskrats, provides better uniformity of water distribution, and supplies spoilbanks in which muskrats burrow. It is sometimes used to change the salinity of marsh waters, thus modifying the vegetation, although this is a delicate maneuver.

Ditches can be made in many ways. Blasting is fast and cheap, and when it is properly done it leaves spoilbanks, that is, banks of earth upturned from the channel when the ditch is made. Use of charges of special dynamite permit the blasting of a long ditch all at one time (Plate 6). Draglines are often used for fast and relatively cheap ditching. This method also provides spoilbanks. Special turning plows or ditchers and marsh tractors are sometimes used in large marshes. The earth removed from the ditch is piled on either side. In small marshes a horse-drawn or tractor-drawn slip scraper may be used, and hand-dug ditches can be built if time is not a critical factor. Special excavators are used on intensively managed coastal areas.

In the North, ditches may need to be 3 to 4 feet deep. Shallower ditches are suitable in the South. They should be at least 2 to 3 feet wide and have a 1- to 2-foot spoilbank. Banks on both sides are most desirable. In places likely to be flooded, spoilbanks should be high enough to afford refuge for furbearers. High spoilbanks of peat, however, are likely to dry out and be destroyed by fire. Usually ditches should have no grade or should be blocked

at intervals to prevent drainage. The most suitable pattern for ditches will vary with the site, but a desirable distance between small ditches ranges from 50 to 150 feet. Large ditches, up to 16 feet wide and 4 feet or more deep, are sometimes used in the coastal marshes, but they are expensive. In the average marsh the small ditch is most satisfactory.

Of importance equal to the ditching is the maintenance of water level, which should be at or very near the ground level. Water-level control is usually handled by dikes or by levees and gates. If it is necessary to flood the marsh in order to establish a desirable water level, this is done by dams, by diverting water from streams, or by pumping water from near-by lakes and rivers. Engineering assistance is usually required to install water-control devices properly. All such devices may be expensive, and the cost may not be justified unless returns from furs can be depended upon.

It will be noted in other parts of this book that fire may be either injurious or beneficial. In wildlife management we are just beginning to learn how to use fire effectively. It has been used in longleaf pine forests of Georgia to check growth of hardwoods and increase wild legumes, a device for improving habitat for bobwhite quail. It has been used to burn off old, dry bunch grasses in Gulf Coast marshes, so as to make the young tender leaves of the new plants available as feed for the snow geese and blue geese that winter there. In marsh management for furbearers, fire also shows promise because it can be used to manipulate vegetation.

Controlled fires are useful in maintaining or creating desired types of vegetation. Regulated burning also allows trappers greater freedom of travel through the marsh. In Texas marshes, for instance, severe fire transforms marshes of sawgrass and cane into cattail, smooth cordgrass, and three-cornered rush, somewhat more desirable plants for muskrats (Lay and O'Neil 1942). Marshes are burned under specified conditions, as when dead plant litter fills shallow-water areas so that muskrats are driven

from them. If burning is to be used to maintain existing vegetation, it should be done when the ground is saturated with water, and when the crowns, rootstocks, or other reproductive parts of desirable species are sufficiently covered with water so that they will not be killed. Fires are easily controlled when winds are light or when the weather is damp. A system of firebreaks and sufficient help to keep the fire under control are required. Muskrat houses should be protected, and scattered clumps of vegetation left unburned to serve as cover.

Control of the habitat is no more important than control of the harvest. As with other crops, it is necessary to know how many muskrats to take, and to save 'seed.' With muskrats this is done by leaving a certain proportion of the population over winter to repopulate the habitat the following season. The number of 'active' houses—those that show signs of internal use—may serve as a rough indicator of muskrat abundance. Available records show an average of more than one muskrat per house—for practical purposes, let us say two; in good years five or more animals may live in each house. Roughly, the more houses within a given area the greater the yield per house. Under conditions of low water and dense vegetation, however, a small number of muskrats may build a great many houses, misleading the trapper into thinking muskrats are abundant. A good habitat sometimes has as many as ten houses per acre, but unimproved coastal marshes average about three. Where conditions are suitable, muskrats dig burrows, which they seem to like better than houses. The trapper can find these burrows by locating the underwater runways leading into them. Burrows appear to harbor larger numbers of muskrats than do houses. The presence of droppings in the vicinity of burrows indicates their occupancy.

When muskrats become abundant they may graze the food plants heavily for 30 or 40 feet around their houses or burrows. This is generally considered an indication of the need to trap, particularly if the grazed areas about several houses or dens meet. Another suggestion of abundance is fighting, which often results

from a high population. This in turn may be the result of some especially favorable condition in an otherwise normal habitat. If so, muskrats may be trapped heavily. On the other hand, it may be the result of an unfavorable habitat condition that has concentrated all the muskrats in a small area. If this is so, it is perhaps inadvisable to trap at all. The reason for the high population, therefore, must be considered.

Muskrat numbers are said to increase and decrease periodically, with peaks every 9 to 11 years. There are also changes during wet and dry years. Observation over a number of years may indicate increasing populations, permitting heavy trapping. Drought or floods often reduce numbers or cause muskrats to move overland. If the movements occur during the trapping season, the animals may be trapped, for similar habitats are likely also to be fully occupied, flooded, or droughty, as the case may be, and mortality of migrating muskrats is usually high.

Muskrats usually produce one to four litters a year, depending on locality and other factors. Litters are fewer in the North than in the South. Mortality of the young is high, but generally enough survive to permit profitable harvests. In years of small numbers, 60 to 70 per cent of the entire population at the time of trapping can usually be taken safely. In good years it is safe to take 70 to 80 per cent. The proportion of males and females in the muskrat catch is sometimes used to indicate when to terminate spring trapping. When females outnumber males in the daily catch for several consecutive days toward the end of the season, experienced trappers believe that enough muskrats have been taken. Some stop trapping when females constitute one third of the total season's catch. As a rule of thumb, traps should be pulled when the catch begins to fall off, unless the decline is the result of only a few days of unfavorable weather. In extensive coastal marshes, large-scale trappers leave their traps in one location only a few days, because the cost of trapping increases as the traps yield fewer muskrats. Hence a breeding stock is automatically maintained.

This discussion of muskrat management is sketched to indicate that if the marsh owner is to produce muskrats successfully, many of the things he must know relate to the habitat—to the land. That such management pays is shown by actual studies. In a recent paper Daniel W. Lay (1945) states that on a 4300-acre marsh along the Texas coast '. . . levee construction and other management has increased the muskrat catch from 1.5 to 5.1 pelts per acre in four years.'

Most of the fur produced in the United States is from wild animals. Our raw fur catch is valued at 60 to 70 million dollars each year. Only one sixth of it is obtained from captive animals. Returns from fur farming, therefore, must remain a poor second to land management that can result in the production of wild furbearers. Care in handling stream margins and ditchbanks, ponds, marshes, and swamps not only yields profit to the trapper; it contributes materially to a great American industry.

V ⇛ PONDS AND WATERS

Ponds

In the past few years, tens of thousands of farm ponds have been constructed in all sections of the country. Many of these were built as a result of encouragement by the Federal Government and the states, from which have come both technical and financial assistance. People too are beginning to realize that a pond has many impressive values when it is constructed as an integral part of a complete, co-ordinated conservation program. In the introduction to a land-use bulletin entitled *Ponds for Wildlife*, Allan and Davis (1941) summarize the values of a farm pond as follows:

> Whether on western ranges, in small pastures of the East, or in the South, better farms mean more and better farm ponds. Better ponds make better farms.
>
> Within the pond area are numerous products of the land that are more or less independent of surrounding areas. The harvesting of ice from a pond or the use of a pond for recreation or for the production of fish, waterfowl, and fur animals are examples of ways in which farm ponds may be employed on farms where the best use of all the land is the farmer's goal. Occasionally a pond serves such useful purposes as providing water for home consumption, maintaining springs, and subirrigating croplands.
>
> A farm pond, also, may have a direct effect on the uses of other land on the farm. By helping to achieve proper distribution of grazing, the stock-watering pond aids in protecting vegeta-

tion on pasture and range. The impounding of waters in farm ponds may contribute to flood control. In some sections of the country water from farm ponds may be used for irrigating crops and establishing vegetation for erosion control. A pond may prevent gully heads from eating back into croplands or pastures . . . or keep silt from covering valuable land below it.

The pond is an outstanding example of a specific practice of importance to both the land manager and the wildlife technician. It nicely illustrates the idea that the best wildlife management is good land management. The pond is usually not built because it is good for wildlife, but because it is an intrinsic part of an intelligent design for land use (Plate 7). Yet a measure more intentionally directed to benefit wildlife would be difficult to devise. It takes but little modification of the average farm or ranch pond to make it worth while in the production of a useful fish and wildlife crop. Some general values of ponds were indicated in the quotation above. The remainder of this section will sketch some of the modifications of ponds that make them useful to wildlife.

THE POND HABITAT

It is probably well to recall that, ecologically, a pond is a rather temporary thing, like a crop field, or a pasture in an area where trees form the climax vegetation. Each of these is maintained as the result of conscious and usually considerable effort. A pond has a tendency to become clogged with vegetation that starts to grow first along its shallow margins. Gradually, as the pond silts up, plants invade deeper water. Old ponds filled with 'moss,' cattails, rushes, tules, spatterdock, pickerel weed, water lilies and numerous other submerged, floating, and shore plants are to be seen almost everywhere. When a pond has reached this stage, it is not of great use for fish, waterfowl, or furbearers. It is on its way to becoming dry land. The land manager and the wildlife manager both have an interest, therefore, in techniques that will maintain the pond as long as possible in an open condition.

Silting is one of the factors that contribute to the rapid development of vegetation. It is consequently of considerable importance that everything possible be done to prevent siltation. One of the first rules is not to build the pond in a stream. Although it may at first seem a logical place to impound water, a pond built in a stream has many disadvantages. It is likely to be subjected to unusually heavy overflows during floods because of the large drainage area generally involved. The dam and spillway are subjected to heavy pressures and the pond itself to unusual sedimentation. Such a pond is especially difficult to manage for fish. A pond built *beside* a stream, on the other hand, is often a good pond. Water for the pond can be controlled and diverted from the stream when it is running clear.

A single rain may deposit several feet of silt in a pond. Within a year or two the capacity of some sizable ponds has been so reduced by sedimentation as to render them useless. Some of the sediment, in new ponds especially, may result from wave action on the shores and the dam. Much of it comes from adjacent fields, pastures, and grazed woods. The answer, as with most land problems involving soil and water conservation, is a cover of vegetation to absorb and retard runoff. Erosion control should be practiced on every parcel of land from which the pond derives its water supply. Otherwise, every rill and gully on the land above will add its share to the silt that settles in the pond.

Among the unexpected things about a pond is that the runoff from a rather small watershed is sufficient to keep it filled, especially where the soil is heavy and the climate humid. It need not be fed by springs or flowing wells, although such ponds are good ones. The rainfall running from crop fields, pastures, and woodlots can be depended upon, in most parts of the East, to maintain a pond. The runoff need only be sufficient to replenish the water lost by evaporation and seepage. The latter depends upon the soil, which should be well tested before construction. Annual evaporation varies from three feet in the humid East to six or more feet in the arid Southwest. A pond with a 6- to 8-foot depth

is usually recommended. As a rule of thumb, it is said that for each acre of water surface, a pond in the eastern United States requires a runoff area of 10 to 20 acres of crop or pasture land, and about double that acreage if the watershed is in woods.

When a pond is being constructed, it is now recommended that, if possible, none of the land that is to be above water level be disturbed. It is occasionally necessary, however, to use earth from an adjacent area to obtain sufficient fill to build the dam. If areas that will ultimately be above water must be disturbed, they should be vegetated as soon as possible. The same is true of the dam itself. Both the surrounding scraped slopes and the fresh earth of the dam will add considerable silt to the pond with every shower and storm. No time should be lost in planting to grass, legumes, or shrubs. In the South, Bermuda grass is commonly used. Often a standard pasture mixture of grasses and legumes adapted to the region will provide immediate cover. Biennials such as sweetclover are useful. Perennial plants, if they can be quickly established, are desirable. Some of the perennials that have shown promise on pond dams are kudzu, memorial rose, bicolor lespedeza, trailing raspberry, dewberry, and coralberry. Large shrubs, especially those having deep tap roots, are not as desirable as more compact plants with branching roots.

In a recent bulletin on fishponds (Davison and Johnson 1944), it is stated that an ideal pond site should be selected to insure:

1. A good reservoir in which to impound water.
2. A water supply as uniform as possible.
3. A water depth of at least 6 feet where the water level fluctuates very little, and a depth of 8 feet or more where thick ice forms or the water level fluctuates appreciably from season to season.
4. A moderately small watershed, to avoid flood problems, and one that is protected so as to keep runoff waters free of silt.

As a means of preventing the growth of aquatic plants along the margins of ponds, technicians now recommend deepening the

pond margins to a depth of 2 feet. The 'feather edge' is no longer favored. The steep edge is helpful in prolonging the life of the pond by preventing encroachment of vegetation, and it is especially useful in modern pond-fish management, in which a pond free of rooted plants is desirable. In the past, vegetation such as rushes, bur reed, arrowhead, bulrush, and cattail was suggested for the uppermost shallow portions of the pond as a silt strain. At best, such plants serve only to retard the flow of incoming water and assist in depositing sediment at the upper end of the pond.

Some technicians now advise deepening the pond edge even at the upper end, where it may be necessary to construct a shallow dike across the pond. The portion of the pond above this dike then acts as a small settling basin where sediment can accumulate. The basin usually becomes vegetated naturally in a short time. Other advantages of deepening the edges are that evaporation is reduced in proportion to the reduction in surface area, and wading by livestock is curtailed.

It thus can be surmised that the construction of a pond has a great deal to do with the ease with which it can be managed and the length of its life. The details of construction are not a legitimate concern of this book, but it should be mentioned that considerable care should be given to site selection, including soil, configuration of the land, dimensions of dam, specifications of spillway, and adequacy of water supply. In many states, permits for pond building are required. They often relate to construction features such as deepened edges that affect the pond as a habitat for malarial mosquitoes. With respect to construction, there are available to the reader a number of publications on small water impoundments (Hamilton and Jepson 1940; National Resources Committee 1938; Davison and Johnson 1944).

From the wildlife standpoint, a pond provides ideal habitat for many fish, waterfowl, and furbearers, and it makes a suitable area also for other game species and for a great many non-game birds and mammals. Recommendations for pond management

vary a great deal, depending in part upon the kind of wildlife to be encouraged, and in part upon the fact that wildlife managers are not yet certain of the best methods. Differences are especially noted between those who wish to encourage fish production and those who want to produce waterfowl and furbearers. This difference is exemplified by the recommendation for fencing. The fish manager does not require the pond area to be fenced. He often prefers a 15- to 20-foot strip of grass bordering the pond. This provides a suitable place to stand while fishing, and it prevents shrubs and trees from growing close enough to the water to shade it and fill it with falling leaves and twigs. Such a margin is most easily maintained by mowing, or grazing livestock. The deepened edge of the pond helps to reduce the muddiness caused by livestock wading in the water. A tank is often placed below the dam for a watering trough.

Those who are interested primarily in waterfowl and furbearers usually recommend fencing, and depend upon it to provide an undisturbed nesting, resting, and feeding area around the pond. To an extent, it may be possible to have a pond that will produce fish as well as furbearers and waterfowl. Certainly muskrats and ducks are often found at the best-managed fishponds and fish occur in the waters of ponds whose margins are choked with vegetation. As yet we do not seem to know a great deal about how to manage a pond for intensive production of both fish and other wildlife.

FISH FROM PONDS

Let us look briefly, first, at the pond as a habitat for producing warm-water fish. Techniques for this purpose have been carefully developed. Since it is not the purpose of this book to provide manual instructions, we shall consider the fishpond summarily, and in its relation to land use. The details of management have been well presented elsewhere (Swingle and Smith 1942; Davison and Johnson 1944; Compton 1943). Although the techniques of Swingle and Smith, developed at the Alabama Agricultural Ex-

periment Station, were originally believed to be adapted only to the South, we now know that the principles are effective elsewhere. During the past few years farmers and ranchers in the Northeast and Southwest have begun to produce appreciable quantities of fish in small ponds, just as land operators have been doing for some time in the southern states.

Pond-fish production is based upon an old, yet scientifically modern, principle. For 2000 years the Chinese have been raising fish in small ponds. In western China carp, and in eastern China several native species, are reared artificially. In early spring, vendors come up the rivers with boatloads of fry—tiny fish less than an inch long. These are sold by the rice-bowl-full to tillers of the soil, who place them in their ponds. During the summer the ponds are intensively fertilized with night soil and other organic materials. The fish thrive until late in the season, when all of them are seined out for food. The farmer starts over again in the same pond the same way the following spring. The production is high—more than three times what we can ordinarily expect from our ponds. Sometimes the pond is especially built on a suitable site in a gully or depression. Sometimes it is the deepened corner of a rice field, from which the fish can forage across the field. Comparable pond-fish management has been practiced for a long time in India, Japan, and the Philippines.

In Europe another type of fish production is practiced as an integral part of the agricultural economy. In the Rhone Valley of France the peasants raise grain in a field for a season or two, after which they flood the field to a depth of two to four feet. Carp are then introduced, and the fish thrive upon the food resulting from the grain stubble, fertilizer, and other organic materials that are present. After a year or two under water the field is drained, the carp are harvested for food or left to fertilize the soil, and grain is once more planted. Some of these fields are several hundred acres in size, and the fish-grain rotation represents a type of correlation in land and wildlife use we have not yet achieved in this country.

Our best-known method of fish production is an attempt to improve on the practices of the Old World. The correlation with prevailing agriculture is exemplified in the way the farm pond is made an integral part of the farm enterprise, and the fertilizing of the pond water is the key to the scheme. The significant difference between fishponds as they are developing in the United States and those of other countries is that we are attempting to set up in the pond a balanced biological condition that will permit the production of fish year after year with the minimum of attention. Sustained yield is the goal.

A pond supports fish in proportion to the fertility of the water, and its productivity is measured in terms of pounds of fish per surface acre. Pond productivity varies from a very few to more than 1000 pounds of fish per acre. In essence, the American scheme of pond-fish management, as Swingle and Smith have developed it, is to set up a food chain, starting with nutrients that are made available by fertilization. Ordinary commercial fertilizers containing nitrogen, phosphate, and potash are recommended. These are applied directly to the water often enough during the summer so that the resulting growth of algae will keep the water murky. These microscopic one-celled plants occur in such numbers as to give the water a greenish or brownish color. The color does not interfere with use of the water for swimming or drinking.

The algae provide food for very small forms of animal life. Upon these live larger animals—myriad aquatic insects. The insects are large enough to support fish that for the most part forage for a living, such as the bluegill bream or sunfish (*Lepomis macrochirus*). These fish, in turn, can provide food for kinds of fish that are largely predacious or carnivorous, such as the large-mouthed black bass (*Huro salmoides*). Both the bluegill and bass are palatable fish that serve well as contributions to the family larder. Thus, in our fish management, we set up in the pond a food chain with links from fertilizer to man. Its success

is measured by the number of pounds of pan-sized fish it produces annually.

A pond can normally be expected to produce 200 to 250 pounds of bass and bluegills per surface acre per year, when the fish are caught by hook-and-line fishing. Experimental ponds have remained in balance for eight years and are still producing. Fertilizing must normally be continued season after season. The fish must originally be stocked in a 10:1 to 15:1 ratio, for experience has shown the most desirable stocking to be about 1000 or 1500 bluegills to 100 bass fingerlings per acre of water surface. These grow into a ratio of about two to four pounds of bluegills to one pound of bass per acre. Once these fish have reached the carrying capacity of the pond in terms of pounds of fish the pond will support, they cannot grow further unless the large fish are constantly removed. Reguar fishing after the first year of stocking is therefore an important phase of management (Plate 8).

The fishpond is gaining favor because it contributes to the best use of the land and because it yields a valuable product. Fishponds can be built in eroded gullies, in seepy areas, or on sites otherwise unsuitable to tilled crops, pasture, or woodland. Because they make productive use of such sites, they are an important land-management measure. The product they yield is a high-protein, vitamin-rich food. Although there are some regions where agriculture is so highly industrialized that farmers live primarily on store groceries, there are vast areas where farming is not sufficiently diversified, or where the diet is so restricted that home-raised fish are highly esteemed. Besides this, there are the recreational, aesthetic, and other values of the pond. The land-use and food values inherent in a fishpond combine to render it a fundamental feature of American agriculture. The scientifically managed fishpond undoubtedly will establish itself in the future as a sound land-conservation practice, in the same category with strip-cropping, terracing, and contour cultivation. Already it has shown great promise.

OTHER POND WILDLIFE

We know less about managing ponds for furbearers and waterfowl than for fish. It is significant that we did not learn practical farm fishpond management from the recognized fisheries experts. It was not until an agricultural experiment station looked carefully into the matter that workable suggestions were advanced. There are both a warning and a lesson here. The warning is to the wildlife manager. If he wants his recommendations accepted by the land operator—who in the last analysis determines whether the recommendations will be applied—they must be applicable, practical, and productive. Unless the wildlife manager can relate his study to the land it will remain theoretical. The lesson is that in the future we might reasonably expect our most applicable suggestions for productive fish and wildlife management to come, not necessarily from the biologists in wildlife management, but from the biologists in agriculture.

When agricultural Experiment Stations and similar research organizations employ more biologists, we shall learn some of the things we need to know about land management in relation to wildlife based on an understanding of agricultural problems, land conditions, and the social and economic aspects of farm and ranch living. To date, the biologists in agriculture have not learned as much about waterfowl, game birds, and furbearers as they have about fish.

Numerous recommendations have been made for planting in the water around pond edges, and on the surrounding land. Aquatic plants are generally selected for the wildlife food they provide. They are usually species easily established and native to the region. The land plants are those adapted to the site; they are chosen for their chances of providing food or cover for wildlife. Ecologically, plantings are an expedient, at least in humid areas, for without expensive maintenance it is just a matter of time until the protected area becomes a wooded thicket. In grass-

land country the protected area may remain a grassy tract indefinitely. We know very little about how to maintain pond environs in vegetation suitable to the animal species we wish to encourage. Therefore we cannot yet make rigid suggestions for managing ponds for wildfowl and furbearers.

Farm ponds, large and small, in the arid and semi-arid sections perhaps even more than in the East, are very attractive to many birds and mammals without special plantings or other improvement. The one general rule of value about handling ponds for waterfowl and furbearers is that the pond environs should be protected from fire and grazing. Ponds then provide particularly valuable homes for species that normally seek vegetated pond or lake margins. Where ponds are built along major migratory waterfowl fly-ways they are intensively used by ducks, geese, and other migrants (Plate 7). Vegetation around ponds is generally useful to farm furbearers, such as muskrat, opossum, skunk, raccoon, mink, weasel, and fox. The pond areas are also frequented by upland game birds and numerous song and insectivorous species. The pond is almost always a place of mild adventure and a center of natural interest.

Waters

Water conservation is a field as broad as soil conservation, and waters deserve a great deal more attention than can be given here. In a broad sense, the term land includes both soil and water, and it is generally so used. Manifestly, we cannot ignore water areas, for the treatment of ponds, streambanks, marshes, swamps, and wet areas is closely tied to the land and its treatment. Lakes, large rivers, and marine habitats are not considered in this book, for, like the great forests, Indian reservations, National Parks, and large wildlife refuges, they are special areas with their own peculiar problems, which are usually the responsibility of an agency specifically charged with their management. But marshes, swamps, small streams, and ponds are so much a part of the land-use picture in the three fourths of the United States that is privately

owned and operated that they demand attention in any treatment of the land. Ponds are discussed above, marshes and swamps in the preceding chapter, and streambanks in the chapter following. This section deals largely with the effect of sedimentation resulting from land abuse and its influence upon aquatic wildlife and water habitats.

SEDIMENTATION

A great deal is heard about damage by sewage and industrial pollution. These are factors gravely influencing streams as habitats for fish and other aquatic life. It is doubtful, however, if they affect streams to anything like the degree that sedimentation does. Especially is this true wherever silt is carried and deposited as a result of accelerated erosion owing to misuse of land. It may be of value to examine a single example of sedimentation within historic time. The study was made and reported by L. C. Gottschalk (1944; 1945), and relates to sedimentation in the harbor at Baltimore, Maryland.

The largest stream entering Baltimore harbor is the Patapsco, which drains land to the west and north of the city and enters the harbor from the southwest. The exploitation of the watershed for tobacco had caused severe erosion even before 1700. By that time numerous Chesapeake Bay settlements had become ghost towns—largely because of soil wastage—and only one, Baltimore, ever developed into a great seaport. The history of Baltimore's long and costly battle with sedimentation is a lesson in the effects of uncontrolled erosion that all conservationists should know.

Designated a port of entry in 1706, Baltimore soon became a large and wealthy town. It has remained a great industrial center and shipping port. Yet almost a century before Baltimore was founded, there was navigation seven miles farther up the Patapsco. Ocean-going ships loaded with tobacco and other products of the land sailed from Elk Ridge Landing to Europe. Today, from the Landing to Baltimore one can scarcely navigate a canoe. Silt has

filled the channel, the stream spreads in fingered rivulets across the sand, and willows grow everywhere.

Sedimentation became so serious by 1753 that a fine was levied for throwing earth, sand, or dirt into the river. Thirty years later a levy was assessed on every vessel entering the harbor, the revenue to pay for a channel survey and dredging. By 1836 the United States began to aid in the work of keeping the harbor clear. Since then the Federal Government alone has spent 17 million dollars for the removal of sediment there, and a large sum has been spent by others. All the while the problem became more serious, not less, for the estuary of the river finally silted up, forcing deposition in the harbor.

Baltimore's sedimentation problems today are not confined to the harbor, for its water-supply reservoirs, built on the rivers above the city, are also filling. A 400-million-gallon reservoir—Lake Roland—built in 1862, was useless by 1916, only 54 years later. Partial or complete loss of several other reservoirs and many mill dams has also occurred, and the present huge impoundments on the Gunpowder Falls north of Baltimore are giving the city serious concern. The very life of the city is at stake.

What is the answer? It centers largely around the use and treatment of the land composing the watershed draining into the harbor. Until its steep slopes are wooded, its rolling uplands are in verdant pasture, and all of its fields come under a system of conservation farming designed to prevent soil loss and rapid runoff, silt will continue to find its way toward the reservoirs and harbor with every falling rain. The solution to this urban problem, like many others, rests in the treatment of our rural lands. The necessity for preventing siltation of reservoirs is forcefully emphasized when we learn that reservoirs already constructed were built on choice and perhaps the only sites for impoundment.

The pity is that this condition prevails not alone in the Baltimore harbor, but in most streams throughout the country. On the Pacific Coast, in the Gulf of Mexico, all along the south and middle Atlantic, in the Great Lakes, in the giant impoundments

of our great western rivers, in thousands of reservoirs, and behind a great number of small dams and ponds, sediment is collecting at an alarming rate. Many small water areas have completely filled with silt, rendering them uselsss. Surveys of 98 reservoirs throughout the United States show that 39 per cent of them will be useful for less than 50 years from the time of their construction, 25 per cent will be useful for 50 to 100 years, 21 per cent for 100 to 200 years, and only 15 per cent for more than 200 years (Bennett 1939, p. 265). The study included such important reservoirs as Byllesby in Virginia, Lake Waco in Texas, Elephant Butte in New Mexico, and the San Carlos reservoir at Coolidge Dam, Arizona. One wonders where we shall impound waters, or at what cost, when these preferred sites are rendered useless.

The results of sedimentation express themselves, of course, in many ways. Sediment often covers fertile bottomlands. In Tennessee, Georgia, and other southern states where this has happened, the choked floodplains created habitats that have increased the number of mosquitoes, which is reflected in public health by a decided increase in the incidence of malaria. It is costly to remove sediment from roads, city streets, and buildings, where it often lodges during floods. Silt interferes with irrigation by clogging channels, and it fills the streams themselves. This is as deplorable to the wildlife manager as it is to the land manager.

It is hard to realize that a river like the Potomac, which is so frequently yellow-brown with mud, was once clear. Yet Father White, an early missionary, wrote of the Potomac in 1634:

> This is the sweetest and greatest river I have ever seene, so that the Thames is but a little finger to it. There are noe marshes or swampes about it, but solid firme ground, with great variety of woode, not choaked up with undershrubs, but commonly so farre distant from each other as a coach and fower horses may travale without molestation . . .
>
> . . . the soyle . . . is excellent so that we cannot set downe a foot, but tread on Strawberries, raspires, fallen mulberrie vines, acchorns, walnutts, saxafras etc: and those in the wildest woods. The ground is commonly a blacke mould above, and a foot within

ground of a readish colour. All is high woods except where the Indians have cleared for corne. It abounds with delicate springs which are our best drinke. Birds diversely feathered there are infinite, as eagles, swans, hernes, geese, bitters, duckes, partridge read, blew, partie coloured, and the like, by which will appeare, the place abounds not alone with profit, but also with pleasure . . .

Just as Father White (Hall 1910) saw a different river and different wildlife, so he saw also different vegetation and different soil—in part, at least, a different environment. And therein lies a lesson, for it is the change in the land which has been the primary change, and the change in the land was brought about by use. If there is to be an improvement in the stream, it must also be related to a change in use.

The biologist looking to streams, or the bays and shore areas into which they flow, as habitats for fish, oysters, shrimp, and other aquatic wildlife that contributes to our welfare, must look to the land also. Certainly erosion silt is a seriously harmful influence on aquatic organisms (Plate 8). It shuts out light, kills bottom organisms that provide food for much aquatic life, destroys substrata for animals like the oyster, and changes the habitat so much that fish requiring clear water and gravel bottoms for spawning may disappear, to be replaced by other species usually less desirable.

INFLUENCE OF LAND USE

The land-use practices that influence waters are legion and beyond the scope of this treatment. In brief it may be said that using land in accordance with its capacity for use is a primary requirement. A general prerequisite is to have cultivated crops only on the land that can permanently support them, and pastures and forests where they are needed to protect the soil. Then there must be selective cutting in existing woodlands, good grass on the range, and sod in the pastures. On the crop fields, contour

cultivation, strip cropping, terraces, grassed waterways, proper crop rotations, and other adapted soil-conservation practices are required. Each of these helps to hold the soil where it belongs and keeps it out of our streams, lakes, reservoirs, and shore areas. It will be a long and costly job so to treat the land that it does not add abnormally heavy loads of sediment to our streams and water areas; but in such approach rests the only permanent solution to the problem of stream pollution by erosion silt.

Anomalous as it may at first appear, the relation between land use and accelerated runoff is nowhere more striking than in our arid areas. In southern New Mexico, E. C. Pancoast, a forty-niner on his way to California, described the Galisteo Valley as 'a large plain of grass' where there were 'many acres planted with corn and other vegetables, and irrigated.' Pancoast walked a plank across a creek there. Today this same stream channel is 25 feet deep and up to 200 feet wide. Irrigation in the Galisteo Valley was abandoned in 1926, when a flood destroyed all the ditch headings.

Another tributary of the Rio Grande, this one south of Albuquerque, tells a similar story. Much of this country has been occupied for a long time by Spanish-Americans. In the lower valley of the Rio Puerco, nevertheless, residents in 1880 described the area as a paradise. Remnants of cottonwood groves and substantial houses prove that there was fruitful agriculture and profitable ranching for a period after that. In 1896 there were 3600 acres irrigated in the valley. By 1931 there remained only three damaged and failing brush and dirt diversion works. Deep channeling of the stream has gradually forced abandonment of irrigation.

In a scholarly treatise by Cooperider and Hendricks (1937), the destruction of old irrigation ditches and diversion works, some of them used for centuries by primitive Americans, is treated at length. Ruins of primitive canals and ancient villages show that irrigation has been practiced in the upper Rio Grande Valley from time immemorial. Originally inhabited by prehistoric peo-

ples, then Pueblo Indians, this area was settled finally by white men after Coronado and his expedition entered in 1539 what is now New Mexico. It is rather significant that, although land has been used for so long in this section, irrigation in the Galisteo Valley, as in many other sections, failed between 1895 and 1915, owing largely to the deepening of stream channels. In other places, as in the Rio Puerco Valley, the passing of irrigation at the same period resulted from silting and filling of the channels.

The reasons for deterioration of the range and forest lands composing the watersheds of these streams may be argued. Climatologists claim, with some effect, that it is a result of the development of a drier climate. Geologists contend that it is a natural consequence of geologic processes. There may be contributing causes, but it is noteworthy that the accelerated runoff and destructive erosion now so evident in the upper Rio Grande watershed—an area of 18 million acres—has followed close upon a recent period of intensive use of the land. Overgrazing, promiscuous timber cutting, man-caused fires, wagon roads, and injudicious dry farming are the immediate cause.

To save this land, a regrowth of protective vegetation is imperative. Vegetation can only be restored through changes in use of the land and the slow re-establishment of native range and forest cover. That this can be done is attested by the fact that in scattered spots that have been protected from overuse there thrives a cover of perennial native grasses, or a reproducing stand of forest trees. Yet the land can probably never again provide the timber and livestock it did for the abnormally stimulated period following modern settlement.

Students of the land problem (Cooperider and Hendricks 1937) see the ultimate use of the land in the arid Southwest in a light of considerable interest to the wildlife manager. They state it as follows:

Game and fish have played an important role in human affairs from the beginning of prehistoric settlement. Taos and Santa Fe were the field centers of the fur trade during beaver-trapping

days. The mountains, with many miles of trout streams and big-game country, where deer, elk, mountain lion, bear, turkey, grouse, and the like are found, and the low country with its quail, waterfowl, and lake fish, are among the best hunting and fishing grounds in the West, although conditions on many such areas could be greatly improved. The opportunities for recreation and field study afforded by the vast areas of mountain wilderness, the health-building climate of the lowlands, the abundance and superiority of things of interest to archeologists and artists, the land of the Pueblo Indians, and the present-day remnants of a sixteenth-century 'New Spain' are bringing recreation to the front so rapidly that these particular resources may some day be the principal assets of the area.

Thus in some regions where runoff is rapid and sedimentation severe, the land may be treated best by use of methods directed at the production of fish and wildlife as the most permanently valuable crop.

In any area where land is so used that flood flow, stream sedimentation, or reservoir silting adversely affect aquatic environment, improvement to the life of the waters will eventually rest in the treatment of the land from which the flood, sediment, or siltation stems. Once more the case is made: If wildlife habitat—aquatic or terrestrial—is to be materially improved, we must look to the use of the land to accomplish it.

VI ⇛ STREAMBANKS AND DITCHES

Streambanks

Pure water is so precious that it is difficult to understand why we do not cherish it and do more to preserve it. We have done very little, as anyone who looks at our streams or tries to swim in our polluted rivers is fully aware. A clear stream is rare these days. Clear, sparkling running water is seldom seen now except at the mouths of springs or in high mountain brooks. Mine wastes, industrial refuse, sewage offal, erosion silt—all these defile our waterways. Some sources of stream pollution the land operator cannot directly influence, but he is in a strategic position to control one of them, namely, streambank erosion on headwater or tributary streams. And to this important feature of land management individual farmers and ranchers, working co-operatively, can make a material contribution.

In some regions, of course, as in the Dakota badlands and in the dissected headlands of arid areas, such as Bryce Canyon, geological erosion is normally active, and man can do virtually nothing to check it. We can do a great deal, however, to keep at a minimum the rate of accelerated or 'man-made' erosion and sedimentation resulting from normal operations on the land.

The principal causes of siltation (Brown 1943) are: (1) sheet erosion by surface runoff; (2) gullying; (3) stream-channel erosion, or the scouring of beds and banks of streams; (4) erosion of cuts and fills along roads and railroads; (5) flood erosion across

floodplains; (6) erosion incident to construction activities, as excavations; and (7) mining and industrial wastes. It is of considerable significance that the most widespread of these—the first three—are those which the land operator has it in his power to control, or at least to influence materially.

Practical methods of controlling erosion along the banks of streams are an important part of land management. No farmer can afford to have a creek cut into fertile bottomland—often the most valuable soil on his farm. By checking such inroads, he not only protects his property but aids in preventing siltation. The streambank erosion-control methods most profitable to employ are also those that create desirable habitats for wildlife along stream margins. Along small watercourses, bank cutting is best controlled by the establishment of appropriate vegetation.

The literature on the subject is full of directions for making special devices intended to accomplish the improvement of streams for fish. There are rock deflectors—in the shape of most of the letters of the alphabet—anchored rafts, boulder dams, stone retards, log coverts, staked trees, wings, triangles, booms, and many other mechanical devices that are expensive to install and tricky to maintain. These are intended to slow and control the current, provide quiet pools or 'lies,' as our English technical cousins call them, control water temperature, and establish nesting areas for fish as well as habitats for aquatic organisms that furnish fish with food. These gadgets are all condoned in the name of environmental improvement, and so they are, of an artificial sort. But it is difficult to see how we can expect them to be applied except on private estates of great wealth or under a subsidized system of public labor. Neither method is economically sound, and there is a more natural and practical way of stream improvement.

Suitable permanent habitats for fish are most effectively developed by the establishment of streambank vegetation useful in the control of bank cutting. This frequently involves analysis of stream channel flow, appropriate bank sloping, careful selection

of plant species, establishment of vegetation, construction of bulkheads designed to supplement vegetative control, and protection of the banks from livestock. It is an expensive treatment, but once established on a small stream from source to mouth, it requires a minimum of maintenance.

The aggregate length of perennial or live streams in the United States has not been exactly tabulated. There are careful measurements of stream length, however, for a few states. A careful survey, for example, shows that Iowa has within its borders slightly more than 15,000 miles of permanent stream (Hoyt and Ryan 1915). There are about 67,000 miles of major rivers in the United States—that is, streams more than 100 miles in length. Estimates for representative localities permit us to approximate the length of permanent stream—river, creek, and flowing brook. Accordingly, the entire stream length is put at well over two million miles, roughly apportioned as indicated in Table 2.

TABLE 2. MILES OF STREAMS IN THE UNITED STATES

REGION	LENGTH OF STREAMS IN MILES
HUMID EAST	
All of the states east of the Mississippi River originally wooded, plus Arkansas, Louisiana, and eastern Texas	1,650,000
PRAIRIE	
The area originally in tall grass cover	140,000
GREAT PLAINS	
The short grass area east of the Rockies plus the original grassland of Oregon and Washington	80,000
COLORADO PLATEAU	
Portions of Wyoming, Colorado, New Mexico, Utah, and Arizona not in the Plains or Great Basin	20,000
GREAT BASIN	
Area between the Wasatch Mts. and the Sierras, from eastern Oregon to southwestern Texas	145,000
NORTHWEST	
Humid areas of Washington, Oregon, and northern California	165,000
TOTAL	2,200,000

The amount of stream per square mile of land surface varies from 1.87 miles in the humid East, as in Maryland, to .02 miles in the arid Southwest, as in Nevada. Thus in many of the areas originally covered with deciduous forest, and still bearing the indelible stamp of this environmental heritage in the landscape, there are nearly 2 miles of stream per square mile of land. In the Southwest, on the other hand, there is but 1 mile of permanent stream for every 50 square miles of land—only one hundredth as much stream per unit of land surface as in the wooded East. Intermittent streams with beds that are dry during a portion of the year are not included in these calculations.

If one selects an arbitrary figure of 12 feet on each side of a stream as the width of land necessary to care for in order to provide adequate protection for the banks, the total acreage may be estimated at 6,600,000 acres. The figure is probably conservative, for many streams will require more than a 12-foot strip along each bank. The devotion of this much land to streambank protection may at first seem unreasonable, but the benefits to be obtained almost demand it. It is also well to note that a large number of our streams flow through farmland. If streambank control is to be accomplished as part of conservation work on individual farms, the magnitude of the job per farm becomes a moderate task. As noted below, steps are already being taken by several states to establish rights-of-way along streams much as we do along public highways.

Not all streams need bank stabilization. Many of them remain in reasonable equilibrium with environmental conditions and present no great management problem. On major streams, bank control requires structural treatment for the most part. But there is a big job to be done if we would attend to eroding channel banks that can be controlled by use of vegetation (Plate 9). As indicated on page 52, 1,000,000 miles of streams on our farms and ranches alone need attention if their banks are to be stabilized and adjacent lands and downstream areas protected.

STREAMBANK CONTROL

Methods for control of headwater streams vary from region to region, with type of terrain and soil, speed and direction of stream flow, watershed characteristics affecting runoff, and other factors. In the South, where winters are mild, there is no damaging action from huge blocks of ice pushed by spring floods, as there is in the North. On intermittent streams, dry throughout much of the year, the plants used for bank control are species different from those where flowing water is always present. In spite of local variation, there are general principles that underlie some of the most important things that must be done to control streambank erosion by vegetative means.

The bank to be treated must usually be sloped. An incline at an angle representing a foot rise for every horizontal foot and a half has been found effective. Treatment should be applied as soon after bank sloping as possible. This not only preserves the slope, but permits establishment of desirable vegetation before a volunteer stand of weeds develops to compete with the planted species. Rapidity of growth is an important factor in the protection of the bank, and this is best achieved when the planted stock is free from the competition of undesired species.

Work on streams in Vermont (Altpeter 1944) has shown that protection by vegetation is provided by both roots and plant tops. The larger roots of woody plants furnish protection from the crushing and tearing action of stones, ice, and water, although large trees are undesirable. Feeding roots, near the surface, make the uppermost soil layer more resistant to erosion. Tap roots, on the other hand, offer little resistance to bank cutting.

Woody plants that have short, dense, and pliable tops have the advantage of bowing under pressure of flood water or ice, thus forming a living blanket on the bank. This lesson is one to remember, for big trees—rigid and heavy—afford little protection. Once uprooted, a tree may leave a bare space subject to washing.

If it falls into the stream, it may deflect water against the bank, thus starting serious cutting.

In the Northeast, it was found desirable to supplement the use of vegetation by laying rock riprap from a point several feet out in the bed of the stream to a point about 5 feet above the normal summer low-water level. This was necessary because the soil usually is not frozen during the spring break-up, when it is particularly susceptible to ice and water action. During other seasons this section is also subject to more scouring than higher portions of the bank. In the North Central States this zone has been protected, at least on small streams, by willow piling. The area needing such protection is usually the lower 5 feet (measured vertically) of the bank exposed to the action of the current.

Above the zone requiring rock riprap or piling, vegetation alone has proved eminently useful to hold streambanks in place. Above the high-water mark of ten-year floods, ordinary plantings are sufficient. Below this mark, brush mats are used, in part to protect the bank until the plantings have had several seasons' growth sufficient to provide an adequate vegetative cover.

It should be emphasized that the outside curves of a stream—the sides receiving the cutting force of the water—present different problems from those on the inside curves. On an inside curve, where the stream is depositing silt and gravel, native vegetation usually develops rapidly, thus increasing the deposition. As a result, the stream is forced against the opposite outside bank, where the curve often tends to become more and more sharp. On some outside curves vegetation may not be satisfactory and rock may be required. Deflectors to break the force of the water may also be needed. Deflectors are jetties of piling or rock extending from the bank into the stream at such angles as to break the force of the current and guide it away from the portion of the bank to be protected.

The establishment of vegetation may be accomplished in several ways. It may be grown by direct seeding of the plants desired. This is usually most effective in the spring, after maximum early

season scouring and silting have taken place. Alder brush, with ripe seeds in the cones, has given good results when applied in the fall. Much needs to be learned of this technique, however, for it is a method so far used only on a limited scale.

The materials employed in constructing bank mats may themselves provide a good source of vegetative cover. On the Winooski River in Vermont, thirty-inch willow or poplar stakes were driven into the bank at thirty-inch intervals. The stakes were straight, of clean shoots, not more than a couple of inches in diameter. They were sunk nearly flush with the ground, sawed off at the top, and driven with wooden mauls to prevent splitting. The lower ends were sharpened just before they were driven. Then willow brush was scattered on the bank and held in place by No. 9 wire criss-crossed between the stakes. The willow believed most desirable in the Northeast is the basket willow (*Salix purpurea*). Speckled alder (*Alnus incana*) and poplar were also used for the mat material. A thin layer of dirt over the mats protects them from drying, although this operation increases the cost considerably.

Cuttings are frequently planted in the fall before the mat is laid. They are driven nearly flush with the ground to prevent damage while building the mat. Fall planting of cuttings without the mat are not successful in the North because of the amount of heaving of the soil from frost action, slippage of the bank, and stream erosion. In the spring, cuttings are sometimes planted through the mat. For cuttings, basket willow proved most useful. Stock about 15 inches long, ⅛ to 1 inch in diameter, is preferred. There seems to be some advantage in the use of rooted cuttings, although the cost of handling, rooting, and transporting them is high.

Seedlings are sometimes used to provide greater variety of species than that which results from the use of cuttings alone. The planting of seedlings of red osier (*Cornus stolonifera*) and silky dogwood (*Cornus amomum*) near the base of brush mats has proved successful where the species are known to thrive and

the planting can be done carefully enough to assure good survival. Where a brush mat is used, the seedlings must be planted before the mat is laid, their stems cut off near the bank surface to protect them. When planting is done through the mat, it is difficult to get firm contact between the plant and the ground. There is, of course, the additional cost of nursery production when using seedlings, as there is with rooted cuttings.

On small streams in the Ohio and upper Mississippi Valley states, considerable success has been achieved by a simple method dependent almost entirely upon vegetation. After the bank has been sloped, long willow poles are laid on it, with their butt ends extending far enough into the stream channel so that they will be covered with water throughout the year. The poles are placed two to five feet apart, each one extending to the top of the slope. They are placed the same day they are cut, but the operation is conducted during a time of year when the willows are dormant. Over the poles a mat of brush is laid, a foot thick where it enters the water, half as thick at the top of the slope. Any bushy sprouts are suitable, although willow lies better than most species. The large ends of the branches are alternately headed up and down the bank as they are laid. Over the brush, old woven wire is laid, and this is held in place by heavy wire strung from posts on top of the bank to heavy stones laid in the water at the base of the mat. The two ends of the mat are held in place by a heavy log well secured so that the mat will not be lifted, especially at the upstream end (Fry 1938; Morehead 1939). With the coming of spring, the logs, their lower ends in the water, sprout, and by the close of the first growing season have produced an abundant cover.

In the Southeast, a simple method of improving streambank vegetation for erosion control consists of cutting out the trees, leaving a shrubby and grassy cover. This has been done only on small streams. Since the trees cut out are usually hardwoods that sprout from the stump, experimental poisoning to kill the tree, both bole and root, has been underway. Such release cutting or removal of trees not only provides a more desirable type of vegeta-

tion along the banks of streams, but reduces shade and root competition between the plants on the stream margin and adjacent crops in the fields. It is a technique even less advanced, however, than other types of vegetative control along eroding streambanks, and needs further proof of its usefulness.

In the Northwest, willows have been used very successfully when supported by loose rock at the toe of the streambank. Otherwise the vegetation is undercut. In parts of California, giant reed (*Arundo donax*) has been profitably used as a live matting, and the shrub *Baccharis viminea* has stabilized banks of intermittent streams, where cuttings 18 inches apart have been planted along the toe of the bank.

In the arid portions of the western United States, problems of streambank control are somewhat different from those in humid portions of the country. There stream flow is frequently intermittent and stream channels are often in very broad, gently sloping valleys extending for miles between distant mountain ranges. A well-defined floodplain as it exists in the eastern United States and in the western mountains is not a common feature of the landscape. The type of runoff is also unique, for flood waters usually roll along a stream channel with a spectacular wall at the head of a flow—moving such quantities of large rocks and debris that the flood announces itself before it arrives by a loud rumbling sound like that of a heavy, moving freight train.

The natural vegetation of the Southwest is usually a desert scrub of some sort, with large woody plants lacking even along the streambanks, except of the major rivers, where willows, cottonwoods, and representative shrubs occur. There larger perennial streams can only be controlled by primarily mechanical means, with the application of considerable engineering knowledge.

Use of vegetation as a streambank-control measure in the Southwest has consisted largely of placing willow brush mats, often to supplement structures. Willow mats are constructed essentially as described for northeastern streams. Plantings with structures are of various sorts. Sometimes willow poles are placed

vertically, sometimes they are laid in trenches (Herion 1939). Frequently plantings are made in the old stream channel behind revetments of piling, cable, and old trees, placed so as to confine a stream to a desirable channel and deflect it from the eroding bank. The species used are generally Dudley willow (*Salix gooddingii*), bluestem willow (*S. irrorata*), fragile or crack willow (*S. fragilis*), and sandbar willow (*S. exigua*).

The plants most useful for controlling streambank erosion, as already suggested, are shrubs that provide a dense, short, pliable cover. As yet we know little of which species to use in various sites to approach the reproduction of a natural plant community more or less permanently adapted to an area. The most desirable plants are those easy to reproduce from cuttings, seedlings, or seeds, and able to withstand invasion by less desirable species. Because breaks in the cover should be repaired immediately, the plants should be readily available and inexpensive to the landowner, who must assume major responsibility for maintenance. Native plants that can be established by cuttings or layering are usually preferable. Others may in time prove desirable. Kudzu (*Pueraria thunbergiana*), an introduced leguminous vine, shows promise in the Southeast as a streambank stabilizer.

In the Northeast the value of willows for streambank control has recently been jeopardized by the spread of a scab fungus (*Fusicladium saliciperdum*), which threatens willows as the chestnut blight once did our chestnuts. Now spread from Nova Scotia as far to the south and west as New York and western Pennsylvania, this disease within the past 15 years has killed both the native and naturalized willows in its path. The poplar canker damages poplars. Insects, as well as certain kinds of fungi, injure some of the plantings.

Use of a mixture of species in an attempt to simulate a naturally adapted plant community is acknowledged to be one of the best defenses against insect and disease attacks. In Vermont a hint of what will survive best has been given by the plants that

established themselves naturally. When planted streambank willows were killed out by the scab fungus, the areas were invaded by red osier, silky dogwood, and speckled alder. Proper planning of work, so that plants are set at a time and under conditions when they will grow fast and become well started immediately, also helps to give them vigor enough to combat disease and insects. The structural phases of the work should be planned for the non-growing season so the plants can be established when they will have every chance for rapid development.

COST AND PROFIT

The control of streams is very costly whether it is accomplished by engineering structures or by vegetation. This should be well understood if streambank work is contemplated. Costs necessarily vary from one location to another. On the basis of work accomplished during the days of Civilian Conservation Corps labor, 1932-42, the cost of bank sloping, laying of mats, construction of willow bulkheads, planting, fencing, and technical supervision amounted to nearly $1000 per mile of stream treated.

The expense involved in rehabilitating our damaged streams is high, although little higher than the cost of making amends for other misuses of land and land resources. The lesson to learn, perhaps, is that it is best to use land in such a way as to avoid eroded landscape and crumbling streambanks. The evidence also points to the necessity of bringing to bear upon the solution of land-management problems the material resources not only of individual land operators, but of communities whose boundaries are of watershed proportions.

Streambank erosion not only damages the land, but also causes other losses. It often damages highways, buildings, bridges, railroads, and other valuable structures. Among the land-management measures of concern to the wildlife manager, the control of eroding streambanks through the establishment of suitable vegetation

makes an outstanding contribution to the general welfare. The benefits to be derived from streambank control are significant:

1. Reduction of erosion and protection of land along the stream.
2. Stabilization of the stream channel, vertically and laterally.
3. Reduction of siltation (by flood overflow) of farmlands and of impoundments and channels downstream.
4. Improvement of habitats for fish in the stream and for wildlife along its borders.
5. Enhancement of scenic and recreational values of the watershed.
6. Reduction of flood runoff and addition to the ground-water supply.

There are special benefits to wildlife from streambank stabilization (Plate 10). On a 144-acre farm in Vernon County, Wisconsin, a soil conservation program was adopted in 1935, and at the same time a bird census was undertaken (Anderson 1942). In 1940, after conservation practices had been well established on the farm, another census was made. During the five-year period there was an increase of 11 per cent in the number of individual nesting birds, and of 20 per cent in the number of species represented. Woodcock, bobwhite, and ring-necked pheasants, which were not present before, were among the birds there in 1940. It is significant that although hedgerows and well-vegetated streambanks occupied less than 4 per cent of the total area of the farm, they harbored nearly half of the farm's nesting birds. It is of interest, also, that the somewhat dense box-elder supported three times as many nests as the more open willows, although the latter were more abundant.

In 1932 Gilmore Creek, Minnesota, was a silt-laden, eroding stream, and what had once been good trout water no longer afforded the angler any promise of return for his fishing. With the establishment of an erosion-control demonstration project in the locality, farmers began to apply conservation practices on the watershed. The banks of Gilmore Creek were revegetated, as a part of the co-ordinated attempt to preserve the soil and soil

resources of the district. Today, after several years of careful land use, the creek flows clear again, and trout once more abound—tangible testimony that man can, if he will, maintain an environment as he likes it.

The mink, whose pelt is valued at a high price, has a marked preference for brushy streams. Minks like marshlands also, but studies indicate that there are four times as many minks in brushy areas as in marshy ones. They seldom wander more than a few yards from streams, although they travel great distances along watercourses. Along stream channels the first rule of conservation is protection of the vegetation from fire and grazing. Although it is well to cut out big trees when they shade desirable shrubs and grasses or threaten erosion on the bank, they need not be removed elsewhere along the stream. It is desirable, in fact, to encourage fruit-producing trees and shrubs, such as persimmon, papaw, plums, and haws. Den trees to the number of 8 or 10 per mile of stream are also desirable if they occur beyond the area of stream flow. They are useful to raccoons, opossums, and skunks. The lack of den trees in many areas is a limiting factor in the production of our more common furbearers.

Just as the benefits from streambank control are widespread and the cost is great, so the responsibility for the work ranks high. In most instances, streambank revegetation should not be undertaken without the adoption of sound land-use practices on adjacent areas. Indeed, it is usually pointless to attempt the control of a caving streambank unless corollary steps are taken to control flood peaks and silt-laden runoff entering the stream. For small streams adapted to vegetative control, this means unified treatment of the watershed. Woodlands must be well protected from fire and livestock grazing so that the earth is covered with a spongy, rain-absorbing blanket of leaf mulch. Pastures must be well managed, with a good turf of water-retaining perennial grasses and legumes. On the cultivated lands, contour cultivation, strip cropping, terracing, suitable crop rotations, cover crops, and the inclusion of green manures and crop residues for incorporat-

ing absorbent organic matter in the soil are helpful. Here, too, the treatment of field borders, contour hedges, gullies, and odd areas contributes both to land use and wildlife welfare by controlling erosion and retarding runoff.

The necessity for watershed treatment in order to assure the success of streambank management emphasizes the community nature of the task. Unless the landowners and operators within a given watershed co-operate toward the common objective of assuring the success of the bank-control practices applied, the work stands comparatively little chance of being permanently successful. Group approach, as through a local land-management or conservation district, facilitates common action and makes possible the most effective completion of an undertaking requiring co-ordinated planning and integrated work upon the land.

Progressive states already have shown the way toward public support of streambank work. Iowa, Minnesota, and New York have leased rights-of-way along short courses of streams. Each stream selected is treated from source to mouth, as a unit. A co-operative arrangement is sometimes undertaken, involving the local farmers through the soil conservation district, the State Conservation Department, and the U.S. Soil Conservation Service. Joint efforts are directed at the successful accomplishment of the undertaking on a community watershed basis. The banks of the streams are sloped and vegetated. The stream right-of-way, for a given distance from the banks, is protected from livestock by fencing. Conservation practices are encouraged on the watershed lands. The Izaak Walton League of America and other conservation groups have also shown an interest in such ventures, all of which are to date experimental.

The fence is an essential part of streambank control, as it is of some other conservation practices. It plays an important role in the maintenance of the plantings. Without fencing, in fact, the work is likely to fail, for livestock not only destroy the plant cover, but aggravate erosion by their trampling. On many small streams, in fact, fencing alone will permit vegetation to develop

sufficiently to contribute materially toward desirable revegetation and consequent bank control. Even fencing, as a bank-control measure, is a watershed enterprise and must follow the stream across property lines to be most effective.

Ditches

In many of the humid eastern states, open ditches have been constructed to carry water away from poorly drained lands otherwise well adapted to the production of the ordinary tilled crops of agriculture. In the arid West, ditches are important in transporting water from permanently flowing rivers and streams to crop fields, pastures, and orchards which would lie drought-stricken and unproductive without irrigation. In these same western areas, the excess irrigation water is drained from the fields and emptied again into the main watercourse by drainage ditches. The free flow of water through western soils, in preventing their clogging with toxic quantities of alkali or salts, is frequently as essential as the application of the water itself.

Thus, in many parts of the country, ditches that carry water to and from agricultural lands are a significant feature of the landscape. Compared with streams, the extent of these ditches is not great. Nevertheless, there are about 140,000 miles of drainage ditches, and nearly the same length of irrigation canals. This quarter of a million miles of canals and ditches provides a real problem in land management, for their banks should be maintained in a desirable sort of perennial vegetation. Such maintenance has not proved easy, largely perhaps because we have not set ourselves hard at the task of mastering it.

The banks of drainage and irrigation ditches are usually composed of raw subsoil turned out by the shovel or drag line that dredged the channel. Not many plants will grow easily on such spoilbanks, as they are sometimes called. Weeds, however, are past masters at accommodating themselves to conditions where more desirable plants cannot grow well, and irrigation and drainage

ditchbanks have become notorious for their support of noxious weeds. In time, woody plants frequently appear on the banks, especially willows along the water line. Soon the willow branches meet above the water, while willow roots, dead branches, and fallen leaves litter the channel and reduce the flow. Aquatic plants also clog the channel, impede the flow of water, cause silt and debris deposition, and impair the use of the ditch. When the channel must eventually be cleaned, the cost is prohibitive because the willows make it almost impossible to use ordinary equipment in the process.

Problems arising from ditchbank maintenance have been so serious that in the East, where ditches were permitted to clog and go unattended for years, the land was finally abandoned. In the West, arsenical compounds are sometimes used to kill ditchbank weeds, and poisons have been added to the water to kill the weed seeds it transported, often without much regard for fish or other wildlife. The land-management biologist here has an opportunity to contribute both to land use and wildlife welfare. The problem is to discover, through trial plantings on typical spoilbanks, the species of herbaceous perennials or other plants of low shrub or herb form that are adaptable to the soil and moisture conditions presented. Properly selected, suitable plants may serve, under some conditions, for livestock pasture. Others, whose worth has been proved, can provide wildlife habitat elements in the form of food and cover, and, being so close to water, they would be doubly valuable, especially in arid areas.

In the Northeast, direct seeding in early spring or summer of creeping bent, rye grass, tall oat grass, and weeping love grass has produced a vegetal cover that adequately protects the banks without impeding the flow of the water through the ditch. At the same time, the cover is composed of species capable of withstanding the competition of undesirable plants. A planting plan that is considered ideal is grass, such as weeping love grass, on the slope, and sericea lespedeza or suitable shrub on the berm. In

the South, Bermuda grass is often used. Protection from livestock is necessary until the cover becomes well established.

On large drainage canals through eastern woodland, the spoil-banks are usually not leveled as they frequently are in cultivated areas. Such woodland banks can be directly seeded to such species as juncea or sericea lespedeza, or bicolor lespedeza, all of which have proved useful in Delaware and Maryland. Shrubs that have at times been recommended for such sites are coralberry, multiflora rose, silky dogwood, arrowwood, hazelnut, bayberry, honeysuckle, and trailing raspberry. Their value has not been established, however, by long trial.

In the western states on irrigation ditchbanks a locally adapted pasture mixture of perennial grasses provides a suitable cover. Dense, low-growing shrubs such as sumac, rose, wild plum, and blackberry have been used to a limited extent. Russian olive grows well under such conditions and is an excellent wildlife food plant.

Like the field border, the ditchbank is both a challenge and an opportunity to the wildlife manager interested in the land. If he can make available to the land operator a type of vegetation that will provide a suitable cover for the ditchbanks, it will have every chance of being used, for it will contribute to erosion control on the banks, prevent siltation of the channel, eliminate a favorite habitat for weeds, and render ditch maintenance a much simpler operation. The species chosen might provide the farm family with wild fruits for pies, jams, and jellies, and they can furnish food and cover for wildlife in a habitat element that is a permanent part of the farm or ranch pattern. To date, our knowledge of how to treat ditchbanks properly is far less than our knowledge of how to treat most of the other habitat elements considered in this book.

The values to wildlife of drainage and irrigation ditches are fairly well recognized, although, as with many other specific landscape features, we have few dependable analyses of the wildlife populations they support (Plate 11). In the upper Mississippi and Ohio Valley states, the distribution of drainage ditches

through fields of corn and grain provides an ideal habitat for ring-necked pheasants. In northwestern Ohio, such lands support a pheasant per acre. The value of drainage ditches as furbearer habitat has been demonstrated, and tabulations of muskrat numbers show that ungrazed ditchbanks will support a harvestable surplus of 10 to 25 muskrats per mile. For the production of furbearers, in fact, drainage ditches even in unimproved form are among the most valuable of land-use features.

VII ⋙ FIELD BORDERS AND ROADSIDES

Field Borders

Among the special principles of wildlife management particularly appropriate to the management of land is the principle of edge. In general terms, this idea is expressed in the statement that the population density of living things varies in direct proportion to the amount of edge per unit of area. So stated, the principle is over-simplified, but as yet there has been no thorough study of the concept, or any published review of work relating to it. Nevertheless, scattered investigations attest to the fact that many insects, a goodly number of birds, and some mammals occur in greater abundance where two types of habitat meet. Thus quail are most often found at the margin of a brushy thicket or comparable habitat fringe.

Although many species are most abundant in edges, the occurrence of some animals, especially those having a large cruising radius, does not support the principle. The antelope, coyote, and elk are examples of wandering species that do not seem to be influenced much by edges. But so many upland game species, furbearers, insectivorous birds, and other kinds of animals respond to edges that recognition of the principle is very useful. In game management the idea is so important that it has been referred to by Leopold as the Law of Interspersion.

It is pertinent that many of the land-use practices treated in this book result in an appreciable increase of edge. The ditch in

the marsh, the shore of the pond, vegetated streambanks, field borders and roadsides, windbreaks, the hedge, and the protected odd area—each of these increases the amount of habitat margin. These practices, therefore, have a special significance with respect to the wildlife that can be supported on the land where they are established. It is not only the additional food and cover provided by the application of these practices that makes them valuable to wildlife; it is also the increased amount of edge they present.

Although the concept of edge has not yet been thoroughly analyzed or evaluated, it has been recognized for some time by practical men. One of the pioneer game managers was the Englishman, John Simpson, who in 1907 published a book on *Game and Game Coverts*. In his book, Simpson discussed a number of concepts only recently treated in this country. 'Marginal covert,' wrote Simpson, 'is that portion of the covert or wood not shaded by trees, and consisting of low trees, bushes, plants and grasses.' He recognized many of the arguments for the development of the woodland edge, and commented:

> First, it may be stated that the best stocked coverts are found where the agriculture is mixed, and that coverts that will suit pheasants will suit nearly every kind of fur and feathers usually classed under the head of game, and which frequent woods. . .
>
> Although good cover of this kind is easily and quickly got up, it is seldom seen. Margins of woods are usually bare, while futile attempts are made to grow underwood among the timber trees by planting species that will not endure shade for long, and which are eaten by rabbits. . .
>
> The great fault of our British woods . . . are their naked margins, which afford next to no protection to either timber crops or game, and, as often as otherwise, the British woodman aggravates the situation thoughtlessly by beginning to fell his timber on the exposed side of the wood instead of on the sheltered side, letting the wind into the whole wood as at an open door. . .
>
> The first duty of a keeper of game should be to concert measures with the forester for preserving a dense margin in all the woods and coverts so as to shut out wind. This concerns the for-

ester as much as the gamekeeper, for trees are just as susceptible to cold currents of air and wind as game.

Simpson points to the nakedness of the English deciduous woods in winter, and recommends plantings for the woodland edge, including conifers for winter shelter, with the tallest species next to the woods, the lowest farthest from it.

A LAND-USE PROBLEM

In the United States during the past decade a great deal of attention has been given to the treatment of a special type of edge—the margin between woodlot and crop field. The need for treatment was accentuated when soil conservationists began to consider a farm as a unit requiring appropriate erosion-control treatment for every acre. Not only the fields, but the streambanks, gullies, and every other parcel of land must be treated in accordance with their needs and capabilities. On many farms an unsightly, eroding, non-productive area existed wherever the edge of a crop field joined woods. It was a problem for the forester and a problem for the agronomist. It was, of course, chiefly a problem for the farmer.

Even though a crop was planted along the field edge, it grew very poorly there, or did not grow at all, because of the shade from the trees and their demand upon the soil for nutrients and moisture. Time, seed, fertilizer, and effort spent on trying to grow a crop on the border of the field were wasted. And yet, although a crop would not grow there, it was treated as cropland. If left uncultivated, weeds and grass appeared, and later young trees grew up from seed, or sprouted from old roots along the edge. When farmers did not cut out the new growth, the woods literally moved into the crop field. There is, in short, nothing good about a neglected, unproductive field border. Yet for years it presented a land-management problem throughout many parts of the eastern United States wherever woodlots were found to meet crop

PLATE 9: TOP. Revegetation stabilizes streambanks and creates homes for many wild creatures. A riprapped slope on the left bank of an Idaho stream.

BOTTOM. Two years later a good growth of willows and other plants has been established.

PLATE 10: TOP. A thick growth of alders, willows, and cottonwoods prevents this Washington stream from cutting out fertile bottomlands.

BOTTOM. The raccoon and many other animals are natural products of wooded stream margins.

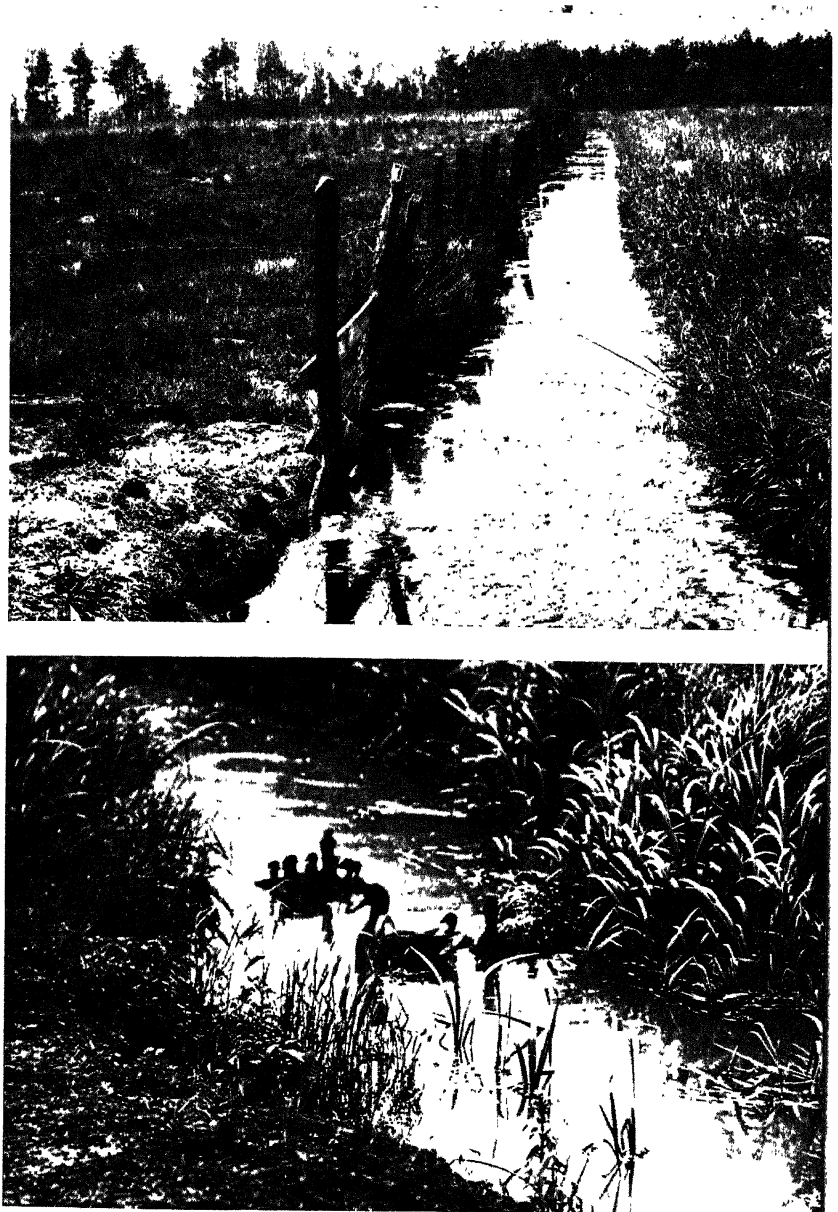


PLATE 11: TOP. The number of muskrats taken from this area trebled after the level ditch was dug.

BOTTOM. Drainage and irrigation ditches provide important habitat elements for ducks and other waterfowl.

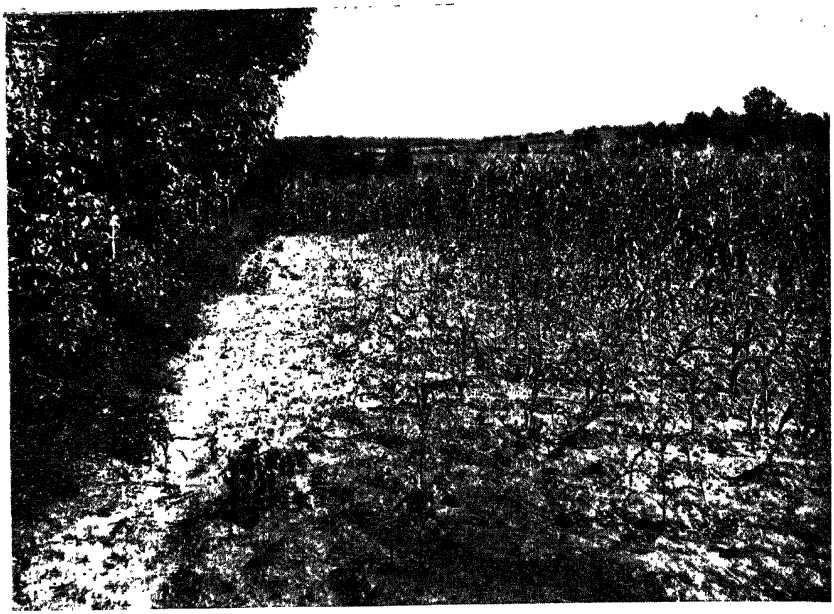


PLATE 12: TOP. Where crops and woods meet the crop suffers and the field erodes. BOTTOM. *Lespedeza sericea* next to the corn and *L. bicolor* against the trees control erosion and benefit wildlife.

PLATE 13: TOP. A border of native shrubs is good for the land and wildlife. BOTTOM. The bobwhite quail is typical of borders, hedges, and odd areas.

PLATE 14: TOP. Roadsides are often badly eroded, like this one in Georgia. BOTTOM. The same area three years later in kudzu and grass offers protection to soil and wildlife.

PLATE 15: TOP. A windbreak of trees and shrubs protects fields and farmsteads and creates a place for wildlife.

BOTTOM. The robin (left) and gray squirrel find homes in windbreaks.

PLATE 16: TOP. A hedge of *Rosa multiflora* makes a living fence that turns livestock. BOTTOM. The yellow warbler (left) and catbird profit by the protective cover of fencerows and hedges.

fields on farm lands. The problem finally was solved by the biologist who recognized in this particular site an opportunity for both erosion control and wildlife habitat improvement.

The technique of establishing desirable vegetation on field borders has been most fully developed in the Southeast, where the problem was serious (Davison 1939, 1941). It was necessary first of all to find plants that would thrive in impoverished soils—plants that, if possible, were perennials and that furnished good erosion-control cover by their growth form or the mulch they laid down. They should be readily available and easily established. They should be attractive species that could be maintained with little labor and expense. They should be able to stand up under an occasional passage of farm machinery and the wash of water discharging from the ends of contour rows. And, if possible, they should provide a productive use for the land. Perhaps because the kinds and the amount of land that can be devoted exclusively to wildlife production is comparatively small, the biologist seized upon the treatment of these borders (Plate 12).

A great many plants were tried. It was believed necessary to select plants that could be seeded directly, for use of nursery-grown stock would be too expensive for the average farmer. In the Southeast a number of native legumes were tried. Among them were the partridge peas, both showy (*Chamaecrista fasciculata*) and sensitive (*C. nictitans*); the mealybeans (*Strophostyles helvola, S. leiosperma*); hairy vetch (*Vicia villosa*); and some cassias (*Cassia tora, C. occidentalis*). Although some of these species germinated and grew rather well, they are all annuals, and they did not reseed themselves. The task of re-establishing them each year ruled them out as permanent border plants.

A number of native perennial legumes were also tested, among them several lespedezas (*L. frutescens, L. capitata, L. stuevei, L. procumbens, L. repens, L. hirta,* and *L. virginica*); American senna (*Cassia marilandica*); Florida beggar weed (*Desmodium tortuosum*), and a few other desmodiums or tick clovers. Al-

though they did not require reseeding, the stands of these plants were never thick, with the result that they could not be relied upon for good ground cover. Several grasses were tried, both annuals and perennials, but they did not do well; they either failed to germinate adequately or were choked out by the competition of volunteer weeds.

After much test planting under field conditions, two plants were finally found that germinated well, produced a good stand, tolerated the shade, could compete with the weeds and trees, and grew well on typical border sites. Both of these were introduced perennial lespedezas. One of them, popularly known as sericea (*Lespedeza sericea*), is a herbaceous, somewhat bushy, greenish-flowered Asiatic plant about three feet high. It has been grown in this country for a long time experimentally, and of recent years has gained some favor as a hay crop in the Southeast. The other, commonly called bicolor (*L. bicolor*), is an Oriental species growing to a height of ten feet. It has long, loose clusters of attractive purple flowers, and has been grown sparingly as an ornamental shrub throughout the eastern states for a number of years.

Both of these plants can be established rather easily by direct seeding. They withstand the demands of the site and the shade and the competition of the trees. They produce a protective cover for the soil by their rather dense forms and by the heavy layer of leaf litter they lay on the ground. The experience of the past ten years has also proved that they will persist and that trees do not easily invade a good stand of them. They seem also to be able to withstand cutting, burning, discing, and foraging by rabbits, and in winter bicolor seems actually to provide a useful rabbit food. Neither of the plants spreads into fields beyond the area in which they are established. They serve, then, not only as a protective vegetative cover, but as an effective buffer between field and woods.

A word about the method of establishing these two lespedezas is in order, for their use illustrates the advantage of seeding over the use of nursery-grown plants. A denser stand is obtained by

seeding. Direct seeding costs three or four dollars per acre. If seedling plants are used, the cost is usually much higher. Cleaned seed or unhulled seed may be sown. For cleaned seed, 10 pounds per acre is sufficient for broadcast seeding; twice that rate is required for unhulled seed. A good seed bed, well firmed, is best, with moderate fertilizing of the soil. Early spring, after frost, when the soil is still moist, seems the best time to seed. Growth may be slow the first year, and even appear disappointing the second year, but by the third year the stand usually becomes startlingly good.

More rapid results can be obtained by sowing bicolor lespedeza in rows, and fertilizing and cultivating it for a year as with other row crops. Row plantings require less than half the amount of seed needed for broadcasting. Recent experience indicates that bicolor lespedeza can best be established by direct seeding when (a) clean, scarified seed is used; (b) seed is covered when planted; and (c) it is planted as soon after the date of the last killing frost as the soil moisture condition will permit.

The recommended field border in the Southeast consists of a fifteen-foot planting of the taller bicolor next to the trees, and a fifteen-foot strip of sericea next to the crop field. In addition to erosion-control cover, the vigorous sericea portion of the border provides a turn-row for teams or tractors working the field. The lespedeza border also adds to the farm landscape a note of beauty in place of an unsightly patch of bare, eroding soil. The flowers of bicolor furnish quantities of nectar much sought after by bees as the source of a mild, light-colored honey. It should be noted that several other shrub lespedezas (*L. thunbergii, L. formosa, L. maximowicksii, L. japonica, L. robusta*) have been tried for border work, but to date none of them has proved to be as useful as bicolor. *Lespedeza cyrtobotrya* is a shrub used to some extent and *L. juncea* has shown possibilities for the lower portion of the border.

What of the value of the field border as a wildlife habitat? It is, first of all, a well-treated edge, and provides food and cover

where it is most likely to be of maximum benefit. In discussing this subject, Verne E. Davison (1945), whose field knowledge of these plants is pre-eminent, writes:

Sericea is probably of greatest value in agricultural game conservation as a cover plant. Quail roost in it at night and coveys frequently are flushed from plantings where apparently they are resting during the day. It appears to be a satisfactory substitute for cover such as that supplied by broom-sedge (*Andropogon virginicus*), an important plant in association with shrubs for quail on idle lands. Land-use programs that provide for proper use of every acre on a farm leave no place for these plants which thrive on waste areas. A need exists, therefore, for sericea or some similar type of cover on farms which are being improved until every acre is well managed. . .

The shrub lespedezas, particularly bicolor, have earned a place in farm-game restoration. The seeds are taken readily by bobwhites, the bark and leaves are eaten readily by rabbits, and the flowers are attractive to honey bees. . . The seeds are not very hard, as evidenced by rapid digestion in the gizzard, and are evidently preferred over the usual favorites—annual lespedezas, cowpeas, partridge peas, and acorns—also usually available nearby. . . Coveys frequent the seed production patches and wildlife borders daily from autumn to spring, and often are there at other seasons.

Although more has been done to modify field borders in the South than elsewhere, the border has been given careful attention in other regions. Native shrubs are planted on field borders in the Northeast. There a twenty-foot border is recommended, with the tallest species placed nearest the woods. Multiflora rose, bayberry, filbert, high-bush cranberry, silky dogwood, and Tatarian honeysuckle are the shrubs used. In the prairie states and in the West, borders of native or pasture grasses are also employed.

Recently Charles A. Dambach, who previously investigated strip cropping and woodlot management as influences upon farm wildlife, turned his attention to the field border (1945). Looking into both the biologic and economic aspects of border management, Dambach examined field edges that were clean cultivated,

others weedy or herbaceous, some in grass sod, some a mixture of grasses and shrubs, and others composed of shrubs alone. He also looked at Osage orange hedges. The studies were conducted in Ohio, but are believed to be representative of much of the Middle West. In Ohio it is not considered efficient to use farm machinery closer than two feet on each side of the fence—thus borders four feet wide are a permanent part of the farm pattern. Wider borders are not considered economical under existing land values and taxes. It is believed desirable to have border plants not more than six feet high, because competition from them would then reduce yields of adjacent crops.

Crop-field borders contain more insects—harmful, beneficial, and other—than adjacent crop fields, and they harbor proportionately larger numbers of small mammals, such as mice and shrews, than near-by fields, at least during the winter. It is of considerable importance that the more the vegetation in a border is like that in the field, the greater the likelihood of the border's serving as a center of infestation of both insects and mammals. Thus clean tilled, weedy, herbaceous, or bluegrass sod borders are more likely to harbor grain- and forage-crop pests than are woody borders. For orchard and many truck crops, the woody borders are more likely to support species harmful to those crops.

To the wildlife manager it is of interest that woody borders are occupied by many more nesting birds than are non-woody borders or the crop fields themselves (Plate 13). If all the field borders of southwestern Ohio were maintained in shrubs, Dambach estimates, the farmlands of that area would support three and a half times the breeding bird population it does now. And birds in Ohio, it may be added, are believed so useful for their insect-eating value that even the bobwhite quail is protected the year round.

Roadsides

The road edge is sometimes decried by wildlife managers as a habitat, because of the disturbance by traffic. Many roadsides,

however, provide desirable permanent habitats for insectivorous birds, and they offer escape cover and travel lanes to many non-game species, both bird and mammal. The modern highway demands broad, gently sloping shoulders, which are best maintained in grass for safety and control of erosion along the right-of-way. Such margins are mowed, and in themselves are of little use to most wildlife. Back of the grassed portions, however, there are often plantings of shrubs and trees, which may be of considerable value to wildlife.

Anyone who has traveled the broad highways of Texas, for example, can scarcely fail to notice the number of birds' nests in the shrubs and trees that have been planted there. This is especially notable in the prairies and other treeless sections, where woody cover is scarce. Even in the semi-arid western part of the state, Texas highways are dotted with clumps of trees and shrubs wherever, along the road, a low place indicated that enough drainage water would collect to warrant the planting of them.

In humid areas, where woody vegetation is more abundant, highway cuts and fills afford opportunities to use plant species valuable to wildlife for both food and cover. As with the field border and many other sites valuable to the wildlife manager, highway sites usually consist of subsoil, or even parent material. From the standpoint of their value to wildlife, not a great deal of planting experience is at hand. Many of the plants useful on eroded sites, however, will grow on disturbed roadsides (Plate 14).

There has been a good deal written about the destructive influence of highways upon wildlife. Lists have been made of the numbers of dead animals observed. The highway toll is particularly striking in the Plains and Far West, where rabbits occur in large numbers. In general, more birds and mammals seem to meet death on highways west of the Mississippi River than east of it. Weedy roadside cover, in country where cover is often rather sparse, and the higher average speed of automobiles on straight open roads may account for this fact. There are also six or eight times as many mammals killed as birds, as might be expected

from the fact that flight affords speedy escape. It may seem, therefore, that establishment of cover along highways is detrimental rather than beneficial to wildlife.

A number of factors seem to influence road mortality among animals, such as distance from cover to the road, glare and shadow from car lights, and weather conditions. In a recent paper in which he tabulated his own extensive observations along 75,000 miles of highways and evaluated the recordings of others, Dickerson (1939) comes to the conclusion that 'roadside cover conditions most favorable to wildlife are entirely compatible with the maintenance of good drainage for the roadbed proper and of adequate protection against bank erosion on cuts and fills.' Inasmuch as drainage and erosion are among the most difficult problems of the highway engineer, there would seem to be little conflict between him and the wildlife technician. Here again, management is the answer. Properly placed clumps of cover, of various kinds appropriate to the site and region, can beautify a highway without interfering with construction, maintenance, or safety, and add an important element to the habitat pattern.

In the Northeast, along the Pennsylvania turnpike, trial plantings show there are three roses that do well. They are multiflora rose (*Rosa multiflora*), rugosa rose (*R. rugosa*), and wichura rose (*R. wichuriana*). Hall's honeysuckle, coralberry, and snowberry are other species that show promise. Among those that have not proved encouraging after four years' trial are shrub lespedezas, bittersweet, Virginia creeper, bayberry, silky dogwood, Tatarian honeysuckle, and black chokeberry. In Virginia, bicolor lespedeza established on highway fills provides food for bobwhites. The birds are not disturbed by the traffic that passes out of sight above them.

Highway revegetation, where woody plants can be used advisedly, has been pointed largely at erosion control and landscape effect. There is no reason why it cannot be modified to contribute to wildlife welfare too. Limited experience indicates that it can. Because soil stabilization is often the first prerequisite, the road-

side exemplifies, like many other areas treated in this book, the almost imperative union of wildlife conservation and soil conservation. It is also another type of edge eminently useful in producing the pattern of habitat most beneficial to wildlife.

Erosion control on mountain roads has been the object of considerable work. Kraebel (1936) has reported on such work in California, where the construction of modern highways in steep mountainous terrain causes spectacular disfigurement of the landscape and serious damage from erosion. The establishment of vegetation on long, exceedingly steep fills and cuts is a major problem. Although retaining walls, cribbing, drop inlet culverts, tunnels, bridges, improved drainage, and other engineering devices are essential, the use of vegetation takes an important place in erosion control even on mountain roads.

On steep slopes above and below mountain roads stakes are driven into the ground along contour lines. Above the stakes brush is laid in bundles, and between the lines of stakes planting is done. The object is to establish as rapidly as possible vegetation of a permanent nature, that is, an association of plant species so well adapted to conditions that they will perpetuate themselves. In order to get vegetative cover as rapidly as possible, however, cereal grasses are sown. They have been more successful than the common pasture grasses and legumes, or native annuals. In order to hold the ground between the sowing of the annuals and the establishment of permanent vegetation, a number of locally adapted species have been advantageously used. Among the species that can be sown broadcast in California are sunflower (*Helianthus annuus*), desert ragwort (*Senecio douglasii*), and other shrubby species of composites in the genera *Chrysothamnus*, *Aplopappus*, and *Encelia*.

Locally occurring species of willow, such as arroyo willow (*Salix lasiolepis*), red willow (*S. laevigata*), Hind willow (*S. hindsiana*), and, at high elevations, Lemmon willow (*S. lemmonii*), are some of the perennial woody species that have given good results. A shrubby composite known locally as mulefat, guatamote, or motie

(*Baccharis viminea*) has shown itself to be an excellent plant for road-slope fixation. The blue elderberry (*Sambucus glauca*) is almost as good as mulefat and willow, for, like them, it freely sprouts from cuttings.

Plants are chosen primarily because they grow well enough to provide the desired cover. Landscape values are not neglected, however, consideration being given to growth form, attractiveness of flower, color of fruit, and autumn leaves. It should be noted also that all of the shrubby forms used for soil stabilization on California mountain roads provide excellent cover for wildlife, and that many of them also furnish food. The fruit of the blue elderberry is known to be eaten by numerous birds, including several quail, and it serves as browse for deer. The composites listed are passable browse plants, as are the willows. The willows are also important in providing food, for their buds are often eaten, especially by game birds in winter.

A little-recognized value of revegetating our highway margins and roadsides is the effect upon aquatic environments. The control of erosion on roadsides obviously holds in place thousands upon thousands of tons of soil that would otherwise find its way into streams, rivers, ponds, lakes, and reservoirs. In many of our rural sections, as almost anyone who has been in the country during a heavy rain knows, the erosion silt moving away from road cuts, fills, and ditches is enormous. What must it be in the aggregate, therefore, when 20,000,000 acres of American land are devoted to roads and highways! Any program to control roadside erosion will contribute materially to clearer streams and waters, and consequently to better habitats for fish and other aquatic life.

VIII ⇛ WINDBREAKS AND HEDGES

Windbreaks

The term windbreak is here used to mean a belt or strip of trees or shrubs that serves to check the force of the wind. It is usually composed of a few rows of woody plants so placed that they protect soil, crops, buildings, roads, or farmyards. Windbreaks are used most frequently, though by no means entirely, in the Great Plains and the Prairie States. In the citrus areas of California and in many irrigated sections of the Southwest they are also conspicuous. In the North they are particularly useful in preventing snow from drifting against buildings or across highways.

As a soil- and moisture-conservation measure, windbreaks have received considerable attention during the past several years. In this discussion no differentiation is made between windbreaks and shelterbelts. Sometimes the former are considered to be only those tree plantings intended to protect the farmstead, buildings, and livestock, whereas shelterbelts are for the protection of crops in fields. The terms are here used interchangeably.

A windbreak is very much like a hedge, and both have been used for much the same purposes. A hedge, in fact, is a kind of windbreak, although it usually is not established to influence wind currents. Windbreaks vary from a single row of shrubs on a contoured slope to elaborate bands of trees designed as shelterbelts across vast open fields. The values of windbreaks are various. Designed first of all to check the wind, they also serve as snow

fences, to control wind erosion, retain soil moisture, protect crops, livestock, orchards, roads, and buildings, furnish fuel and fence posts, provide bush fruits and nuts, afford useful honey plants, add attractiveness to the farm, and provide a shaded place for family picnics and recreation.

Windbreaks also create cover and food for wildlife in areas where woody cover is usually rare or lacking. The wildlife assets of windbreaks, in fact, rank among their most important secondary values. They are much used by both birds and mammals, and in the Plains and Prairie States they are one of the outstanding wildlife-land-management practices. Before looking especially to wildlife values, let us consider some other features of windbreaks.

Windbreaks have long been planted in other lands, and nearly a century and a half ago German immigrants to Russia in the region north of the Crimea evidenced an interest in them that remains in the U.S.S.R. today. In Russia the plantings are most prominent in The Steppes, where the soils are dark and deep and trees are found only along the watercourses, as in our own prairies. This region extends in a broad band from the Ukraine westward across Russia and most of Siberia between 50° and 60° N. latitude, although in European Russia it reaches far to the south of these parallels. A level to slightly rolling landscape stretches from south of Moscow nearly to Stalingrad and the Black Sea, between the humid forests to the north and the arid semi-deserts to the south.

Although some of the pretentious plans of the past to afforest The Steppes have been dropped, numerous old experimental plantings remain as check plots. Five-year plans before World War II called for extensive plantings of shelterbelts in Russia. It is of interest to learn that, just as we have used Russian species such as the Siberian peatree and Russian olive, they have used our Osage orange, white ash, and honey locust. A native oak (*Quercus robur*), however, is considered their best tree. Indeed, chief reliance upon native species is one of the lessons to be derived from Russian experience. It was also found that if trees

or shrubs unlike the growth form of the original vegetation are used, great care is necessary if the plants are to survive. Belts of trees planted in a width of more than 50 feet have been most commonly used.

In Hungary, on the plains southeast of Budapest, windbreaks, usually of 3 to 6 rows of trees, have also been used for some time to protect crop fields, orchards, and vineyards. Species have been used that are well adapted to the soil, topography, and locality. In the low-lying peninsular portion of Denmark, open to the full force of the North Sea winds, a potentially fertile agricultural area is now subject to drifting, inundating sands. Windbreaks and hedges, including conifers among the species used, are planted there to reduce the force of high wind velocities.

In the prairie provinces of Canada—southern and central Alberta, Saskatchewan, and southwestern Manitoba—windbreaks were planted by the first settlers. Their failures and difficulties gave rise to governmental experimentation, and today the species most used are box elder, green ash, Siberian peatree, Russian olive, willows, various poplars, Scotch pine, and white spruce. To protect farmsteads, five to seven rows are used; for fields, two to four.

In the United States our experience dates from early settlement of the Middle West, when special encouragement was given by the government for the establishment of woody plantings. We can now question whether it was to our credit to encourage trees in the Plains. The urging was as recklessly given for such plantings as it was for the settlement of the Dust Bowl and sagebrush desert. The trees of the Great Plains occurred naturally only along the watercourses—the uplands were covered with prairie grasses. Yet in 1866 the Commissioner of the General Land Office, in his message to Congress recommending tree planting, made the following extravagant plea:

If one-third the surface of the Great Plains were covered with forest, there is every reason to believe the climate would be greatly improved, the value of the whole area as a grazing country won-

derfully enhanced, the greater portion of the soil would be susceptible of a high degree of cultivation [U. S. Forest Service 1935, p. 51].

In 1873 Congress passed the Timber Culture Act, which provided for planting 40 acres of trees to be spaced not more than 12 feet apart. The Act was variously amended in subsequent years in attempts to make it work, and we now have good reason to question its value.

As shown by an analysis of the old groves planted by early settlers in North Dakota, the trees most commonly planted were box elder, green ash, silver maple, Russian olive, American elm, aspen, and various willows and poplars (Scholz 1935). These were usually in the required forty-acre blocks. In 1931 a third of these groves were dead or dying. Reasons given for their failure were that the species used were not adapted to the climate or site, or that they died as a result of drought, grazing, fire, insects, disease, and other causes.

The final comprehensive attempt at tree growing in the Great Plains was the pretentious shelterbelt project of recent years. Starting in 1935, scattered windbreak plantings were made throughout a hundred-mile belt stretching down the 100th meridian from the eastern Dakotas through central Nebraska and Kansas into northern Texas, where it skirted the east edge of the Panhandle. This project, started with plantings across crop fields and generally along roads and in isolated swales, has dwindled largely to a series of farm windbreaks, planted where the trees can be given some attention, such as supplementary moisture and cultivation.

In 1914 the Federal Field Station at Mandan, North Dakota, began a study of the growth and survival of deciduous trees in shelterbelt experiments, upon which they later published the results of their twenty years' observations (George 1936). Admitting that early settlers had obtained only limited success with trees in the Great Plains, the Station planted 22 combinations

of 18 species that were considered to be most useful for such purpose. For the twenty-year period the annual rainfall at Mandan averaged about 15 inches; the temperature varied from 100° to −43° F. Average seasonal evaporation was 34.5 inches, and wind velocity about 6 miles per hour. Poplar, willow, and birch were heavily killed back, and only seven species, four of them shrubs, maintained satisfactory growth and survival. The satisfactory plants were Chinese elm, green ash, box elder, chokecherry, Siberian peatree, buffalo berry, and American plum.

There has been a great deal of support for broad windbreaks, largely by foresters who promise a yield of wood products from the trees. The very purpose of a windbreak, however, is to check the force of air currents, and this can be done as well by a narrow as by a broad barrier. The effect of the barrier depends primarily upon its density and its height, not upon its width. Although, as already recognized, windbreaks may have numerous secondary values, the most they can be expected to provide in the way of wood products is an occasional post and a little fuel wood. In most instances, yields of either cannot be much more than incidental.

Pleas have recently been made for narrow windbreaks. In the southern Great Plains, for example, a number of nine-year-old shelterbelts in Oklahoma and Texas indicate the value of narrow plantings. Established largely to protect fields of cotton, these windbreaks consist of a row of cottonwoods and another row or two of a more dense species planted to close in around the cottonwoods as the latter get older and open up at the base. A forester (Stoeckeler 1945), who studied these windbreaks, recently concluded:

> . . . in those parts of western Oklahoma and northern Texas where rainfall is about 24 to 26 inches per annum, results of experimental planting and data on crop response tend to favor planting of rather narrow shelterbelts of one to four rows on the most favorable of sandy sites where intertilled crops are grown and where wind erosion is a problem. . . The alternation in a

single-row belt of two species of widely different growth habit and form, such as cottonwood and mulberry, proved to be quite successful.

Thus not only a narrow belt, but a single row of trees may serve as an adequate shelter against the wind. Single-row windbreaks, of course, have been used in irrigated sections for some time, where closely spaced Lombardy poplars, eucalyptus, and other tall slender trees are grown to protect crop fields.

Whether they are broad or narrow, of trees or shrubs, windbreaks are an established land-use device in open, flat country where winds blow strong. As a permanent part of the landscape in prairies and plains, the windbreak is of considerable value to wild creatures (Plate 15). When composed of trees and fruiting shrubs, as in the modern windbreak, these plantings afford both cover and food for wildlife. In winter they serve as especially valuable shelter, and in summer song and insectivorous birds find refuge in them, as shown by the fact that the trees often become crowded with old nests. Game birds such as pheasants, quail, and Hungarian partridge are often flushed from windbreaks. Mammals use them too, for squirrels, rabbits, and furbearers such as the skunk and fox are to be found in them. In brief, windbreaks provide an important environmental element usually lacking in more or less treeless country.

Hedges

Most of us in modern America are accustomed to thinking of a fence as composed of taut strands of wire stretched upon steel or wooden posts. Yet the barbed-wire fence is a new idea—developed along with the settlement of the West—and its history is as exciting as most other chapters in the story of American expansion. Drawn wire, barbed or smooth, was not known to the ancients, who knew only wire made from beaten metal plates cut into strips that were then rounded by more hammering. Such wire could be produced for special uses only. The art of wire

drawing appeared in Europe in the fourteenth century; it did not reach England until the second half of the seventeenth.

Barbed wire, consisting of twisted steel strands holding short, sharpened spikes between them, was a mechanical achievement first realized less than 80 years ago. Smooth iron wire was all that had been available previously; it not only shrunk and stretched with changes in temperature, but failed to hold livestock that pushed against it. The opening of the Great West, where timber was scarce or absent, demanded a special fencing material, and human ingenuity produced it. But wire is not the only good fence material. During recent years there has been renewed interest in a very old type of fence, the hedge.

The word fence is short for defense, from the Latin *defendere*, to protect from attack. Primitive man must have used barricades to shield the open door of his cave, and when he first raised crops there must have been fences of brush and logs and stones to protect his plants from the beasts. Finally, as crops occupied more and more land, the animals, then domesticated, were confined and fenced apart from the crops. At some time in the history of fencing came the idea of a barrier that cattle or the wind couldn't push over, that didn't always have to be mended, or that wouldn't rot out. This was the hedge of living plants.

The hedge, as a land-management device or as an ornamental screen, is mentioned in the Bible, which refers to 'the highways and hedges,' and the word in its figurative sense is also used there by the prophet who lamented he was 'hedged about.' Homer tells us that Laërtes was planting a hedge when his son Ulysses returned from the Trojan wars, and the Latin writers frequently mention thorns as plants for live fences. Columella wrote of plants for hedges to protect bee colonies, and Varro, another Roman agriculturist, when he listed species of bee-plants for year-round use, recommended shrubs to shelter the hives.

At least 600 years ago the Italians were growing hedges of English hawthorn (*Crataegus oxyacantha*). A native of Europe and North Africa, the hawthorn as a hedge plant has been used

in England since the Roman invasion. It is no accident that the Teutonic root, *haga*, meaning enclosure, from which we get the word 'hedge,' crops up as *haw* in hawthorn. The hedge is a time-tried instrument, and deserves more attention than Americans have given it. Like some other land-use measures we must learn anew, modern methods of soil and moisture conservation focus our attention upon the uses and values of the hedge.

In the eastern states hedges have been tried for a long time. The early agriculturists of Philadelphia tried numerous species, and wrote at length of their merits. Many trials were made with the English hawthorn, of course, but due to the attacks of fungi and our dry summers, it never succeeded. It should be recalled that in England the climate is not only more humid than here, but hedges are rarely planted except along a ditch where water is available.

Experience in the American colonies pointed to a number of plants of possible value as hedges, and as early as 1810 we find William Rawle writing that, even if the English hawthorn, or white thorn as it was usually called, 'accorded better with our climate than from the experiments in the vicinity of Philadelphia . . . the difficulties and expense of importation form sufficient reasons to reject it.' Rawle (1811) was anxious to produce a hedge fence by direct seeding—a trick we haven't learned much about to this day. He found that by steeping the seeds of honey locust for twenty-four hours in a solution of powdered brimstone he could render them repellent to field mice, and he succeeded in obtaining nearly perfect germination.

Many other plants were tried for hedges at that time, for example, sour gum, white mulberry, sycamore, red cedar, black haw, hemlock, buckthorn, crab apple, native hawthorns and others. Many of these were trees, requiring more maintenance than a field hedge justifies. Some, however, like the hemlock, have proved to be among our most beautiful and satisfactory ornamental hedges.

Early interest in hedges is shown in the Report of the Commissioner of Patents for the year 1857, in which there appeared a list of spinescent shrubs native to the United States and Territories west of the Mississippi that deserved trial as substitutes for the hedges commonly used. Among the plants recommended for the Southwest by John Torrey (1858), famed botanist of that period, were Emory's thorn (*Holacantha emoryi*), two indigenous barberries (*Berberis canadensis* and *B. fendleri*), lotebushes (*Zizyphus obtusifolia et al.*), mesquite, screw bean, ocotillo, and catclaw.

By this time, in the southern Great Plains, a plant was coming into favor that was to prove the most widely used of all our native hedge pants, the Osage orange. It is variously called bois d'arc (bow-dark in Arkansas and the southern Great Plains), bow wood, yellow wood, Osage, orange apple, hedge apple, and just plain hedge. Jonathan B. Turner has been credited with changing the agricultural pattern of the midwestern prairie when he introduced the Osage orange in 1845, and by 1848 Turner was convinced that 'God designed osage orange especially for the purpose of fencing the prairies.' In 1858 John A. Warder, commenting on the lack of timber for wooden fences and the absence of rock on our best farms, presented for public consideration a 290-page book on 'the useful, the economical, the practical, and at the same time, the ornamental, Live-Fence or Hedge,' a book devoted largely to the merits of the Osage orange.

But in 1867 came the first patent for barbed wire, and the wire fence began to stretch across the Plains, its virtues extolled. Did it not permit a man to see through it to his land beyond? Did it not permit tumbling weeds to roll under it so they did not stack up in windrows? Did it not require a minimum of maintenance? The fact that a wire fence is only as permanent as the posts that support it was not so significant in the arid sections of the country where conditions are less favorable for wood-destructive organisms than in the humid East. And now

we have steel posts and, finally, the electric fence, all highly useful for particular purposes. But none of these has honestly deposed the living fence or hedge. It remains, if we employ it reasonably, a valuable land-management device.

In the United States, our impressions of living fences are today gained largely from overgrown fencerows or old hedges of Osage orange. The Osage orange is a tree that grows easily out of hand if not kept trimmed. An overgrown fencerow is usually a symptom of poorly used land and is not to be confused with the type of hedge considered desirable as a sound land-management device. A desirable hedge is one that is composed of species of plants that do not require much attention to preserve them in low, well-defined form and that does not sucker or otherwise spread. A hedge should be carefully located to fulfil a specific land-use purpose, either where it can serve as a fence or as a supplement to erosion-control measures applied to the land.

The modern hedge promises to play a distinctive role in the new pattern of conservation farming. Such a hedge is placed on the contour, and its advantages have been enumerated (Edminster 1939a) as follows:

1. *Retards runoff*—checks flow of water across broad slopes, thus reducing its scouring and carrying power.
2. *Checks soil erosion*—by checking runoff, reduces silt load transported.
3. *Moderates wind and loss of soil moisture*—reduces drying action of wind and increases absorption of moisture by retaining snow cover and checking runoff.
4. *Aids adjacent conservation measures*—serves as a permanent guide and marker for contour operations, as plowing and strip cropping; protects and supplements the grass cover when planted above a diversion terrace.
5. *Supplements crop pest control*—insectivorous birds and mammals, as well as predacious insects, live in the hedge.
6. *Benefits wildlife*—provides nesting sites, cover, food, and travel lanes for birds and mammals.
7. *Improves landscape values*—helps to make the farm a more attractive place in which to live.

It will be noted that these values of the hedge do not include its use as a fence, for the contour hedge as a conservation device is not intended especially for this purpose. In fact, the species recommended, except multiflora rose, which is discussed below, do not provide an effective barrier against livestock.

Hedges are best established along boundaries between pastures and crop fields, or between crop fields and meadows or orchards. Under some conditions they may be set in cultivated fields, especially where a barrier against erosion is needed and strip cropping or terracing is not deemed adequate. They may be established above or below permanently vegetated diversion ditches, but their use within cultivated fields will probably remain limited to special conditions.

In the East, where hedges have received most attention, the species which have been most useful in farm conservation programs are:

Bayberry	*Myrica carolinensis*
Multiflora rose	*Rosa multiflora*
Hazelnut or hybrid filbert	*Corylus americana*
Silky cornel	*Cornus amomum*
Tatarian honeysuckle*	*Lonicera tatarica*
Arrowwood	*Viburnum dentatum*
High-bush cranberry*	*Viburnum trilobum*
Bicolor lespedeza	*Lespedeza bicolor*

* Suitable for poorly drained sites.

To compose a desirable hedge, one species may be used, but two or more give suitable variety. They may be planted in a single row a foot apart, or set with two-foot spacing between the plants, staggered in the rows. Although direct seeding is a desirable feature of shrubs for hedges, only bicolor lespedeza, among those listed above, is successfully seeded in the field, just as it is for field borders (see p. 117).

Although it is often held, largely by devotees of 'clean farm-

ing,' that a hedge will increase weeds, harmful insects, and injurious rodents, quite the opposite is true of the well-planned and properly established hedge. Furthermore, plants of neat shrub form do not shade adjacent areas and, if species are correctly selected, will not spread. If hedges are planted along one side of existing fences, they do not interfere with fence maintenance, and if planted as part of a general conservation plan for a farm, they can be established where they do not interfere with the movement of farm machinery from one field to another.

Conservation values of hedges have been emphasized by the recent war-time scarcity of strategic materials, for if appropriate species are selected, a hedge can be impenetrable enough to be used as a fence. The 425,000 tons of barbed and woven wire produced in 1935 exemplifies the amount of steel annually put into fence wire in the United States. This wire is coated with valuable copper-bearing zinc. In addition, transportation required to haul wire and fence posts adds to the cost of constructing and maintaining wire fences. As a substitute and to replace the once ubiquitous Osage orange of the prairies, a plant has been found that shows unusual promise. It is the many-flowered or multiflora rose (*Rosa multiflora*).

Those who have conducted experimental work with multiflora rose have made the following statement (Steavenson *et al.* 1943):

> A living fence plant must be dense and thorny enough to repel livestock. It is not paradoxical to say that it must be vigorous in growth habit yet restricted in height and spread. Like osage, it must be easy to propagate, cheap to produce, economical to plant, and able to thrive under various soil and site conditions. Contrary to popular belief, osage orange does not possess the latter ability and the A_1 soil horizon on which old osage hedges grew is rarely available for modern hedges.

Multiflora rose fits these qualifications. An Asiatic introduction, it is easy to propagate and grows well. Planted at one-foot intervals in a single row, it forms a dense, head-high, shrubby growth, with a favorable appearance in flower, foliage, and fruit. To obtain

best growth on depleted sites, it is well to prepare the soil, apply manure, mulch or cultivate the row, or plant in a furrow that will retain moisture.

Once established, a row of multiflora rose provides a barrier that will turn horses, cattle, sheep, goats, and even hogs if their noses are ringed. It does not spread from the row, and has been used effectively in soil-conservation operations to keep livestock from eroded areas that were being revegetated. Gullies in pastures, draws, and streambanks can be protected by a living barrier, which in itself has numerous advantages not possessed by a wire fence. The rose provides excellent escape cover for wildlife and produces quantities of fruit which, persisting throughout the winter, serve as a food reserve for numerous birds.

Several recent studies indicate the value to wildlife of the type of hedge considered most appropriate from the land-use standpoint (Plate 16). George A. Petrides (1942) has recently reported on a winter study of New York hedgerows in relation to wildlife. A total of 93 species of birds were observed in hedgerows near Ithaca, New York. Most of the birds were migrants or wanderers that frequent other habitats, but among them were typical hedgerow species, such as the ring-necked pheasant, catbird, brown thrasher, robin, yellow warbler, purple finch, goldfinch, slate-colored junco, and several sparrows. During the winter of 1939-40, when deep snows covered almost all of the ragweed and buckwheat present, 15 species of birds were observed in hedgerows in an area where all the surrounding land was open fields. A dozen species of mammals were found to inhabit fencerows, which proffered homes, travel lanes, or other refuge for cottontail rabbit, woodchuck, gray squirrel, red squirrel, white-footed mouse, meadow mouse, and others.

Petrides summarized his observations of New York hedgerows as follows:

Winter bird populations were concentrated in hedgerows which, although deficient in late winter foods for birds, provided some provender and cover for travel, escape, and feeding in otherwise

open, snow-covered country. Strips of land near hedgerows were most thoroughly hunted by feeding birds . . . Cottontail rabbits in hedgerows lived exclusively in woodchuck burrows during late winter; they shunned hedges lacking these retreats except for limited feeding . . . Both gray and red squirrels used hedges in feeding and traveling . . . The activities of both birds and mammals were greatest in low, shrub-stage hedgerows where fruit, browse, and cover were most abundant. All of the species of hedgerow plants eaten by wildlife were most common in hedges of this type. . .

Hedgerows in the shrub stage are of most value to wildlife. In natural hedgerows, the shrubs should be preserved by removing associated species of greater potential height. For greatest efficiency in soil and wildlife conservation in the central New York region, it is recommended that contour hedges be composed entirely of shrubs and vines. They should be from 6 to 10 feet high, 12 to 15 feet wide, and of good density near the ground. Their plant composition should provide late winter foods for wildlife and be so controlled as to insure permanency of growth form.

The managed hedge, like the other practices described in these chapters, is therefore seen to have not only a land-use value but an important influence upon wildlife as well.

IX ⇛ GULLIES, ODD AREAS, AND SPOILBANKS

Gullies

A GULLY is a sign of worn-out land—land misused and eroded almost beyond repair. In woodlots, pastures, or crop fields, gullies indicate a type of past use not in keeping with the capabilities of the land. In crop fields gullies show up after sheet erosion has gradually carried away the topsoil, and rill erosion has dug rivulets across the slopes into the subsoil beneath. This is the way of erosion—first sheet erosion of the topsoil with every heavy rain, then tiny rivulets as the condition gets worse. Because the rivulets can easily be erased with plowing, even rill erosion is not always apparent to the untrained eye. But the rivulets become larger, and there comes a day when the farmer can no longer plow across them. They become deeper and deeper, and gullies are born.

Where the water coursing down a gully empties into a stream or ditch, a tiny waterfall appears. Here the pouring water undermines the edge of the bank, which caves in, and the point of fall moves up the channel, which assumes a U-shaped cross section. As it moves up the gully, the fall increases in height. The undermining often proceeds rapidly, especially where there are soft and sandy subsoils. When falls do not develop, V-shaped gullies result, especially in the upper reaches of drainage areas where slopes are moderately steep and the contributing areas are small. Under other conditions, particularly in mid-latitudes, alternate freezing

and thawing may cause gullies with an irregular castellated appearance (Jepson 1939). Gullies may develop to enormous proportions, simulating such phenomena of geological erosion as the famous natural canyons of our arid Southwest.

Whatever their particular type or extent, gullies are an unfailing sign that something is very much wrong with the way we have used the land, and a final warning that something must be done. Gullies not only make it virtually impossible to cultivate a field, they endanger cattle grazing in a pasture and destroy trees in a wooded area. They often encroach upon public as well as farm buildings, undermine fills, bridges, and culverts. They increase maintenance costs on highways, railroads, and other structures. Yet the most costly of all damage is that which has been done to the land.

The only way to repair gullied land is to look to the land—not only to the gully but to the whole watershed, large or small, that contributes runoff to it. The watershed must be properly treated, and the use practiced there must be brought into agreement with the land's needs and capabilities. If it is steep land, it may need to be reforested. If it is less steep and erodible, a pasture cover of adapted grasses may suffice to hold the remaining soil and check the runoff. Perhaps a revised system of farming even tilled fields —with contour cultivation, strip cropping, and terracing—will be enough to retard gullying and further accelerated loss of soil. Even with such treatment, it may be necessary also to divert the water from the gully by a ditch above the gully head.

Frequently a gully across a crop field, if it is not too deep and the slope of the field not too steep, can be converted into a grassed waterway which will safely carry runoff from the slope. Meadow grasses on the waterway render it productive of a useful crop, for they may be cut for hay. In pastures, a good sod of grasses and legumes can often be re-established in gullies, even though it may be an expensive procedure. The water can be diverted, the banks of the gully sloped, fertilized, and seeded,

with grazing eliminated until the plants are established. Even then, the number of animals permitted on the pasture after the grass has stabilized the gully will have to be reduced below the number grazing there when the gully formed, and adequate soil- and water-conservation practices may have to be applied to adjacent lands.

Gullies in woodland can also be redeemed by careful treatment. Once their cause is determined and steps taken to remedy the situation, the gully should begin to support trees again and become a part of the woods. Wherever the inherent capacity of the land for use over a long period of time is the production of tilled crops, livestock, or wood products, gullies should be so rehabilitated and subsequently managed that they and the areas contiguous to them can once again contribute to such production (Plate 17).

Wherever they exist, whether in crop fields, pasture, or woodlot, gullies may be treated as wildlife land, at least until they have once more become a productive part of a field, pasture, or woodlot, and they can be made to contribute to the economy of the farm or ranch on which they occur. Managed for wildlife, gullied areas can be productive of a wildlife crop instead of remaining idle or worthless. Treatment of gullies may consist of transforming them into ponds, as discussed in Chapter V, but it more often consists of establishing a type of productive vegetation, such as that suitable to the support of a desired kind of wild bird or mammal. Because gullies occur under widely different conditions of climate, physiography, soil, and native vegetation, specific recommendations for their treatment are local or regional in nature.

This is an appropriate place to pause and examine those special plants that have been used most for controlling erosion, including those used in gullies. They are tabulated in Table 3, with designation of the soil-conservation practices in which they have been employed, and their wildlife value. The list does not include (1) lespedezas and standard mixtures of grasses and legumes used

commonly for pastures and meadows, (2) littoral plants occasionally used to decrease siltation and prevent erosion by wave action on pond shores; or (3) many species and special strains still being tested and developed for erosion-control purposes. It does include species produced in nurseries for planting or seeding in erosion-control work.

It is of significance to those who wish to integrate wildlife conservation and land use that the plant species most successful for erosion control are of paramount value to wildlife. In the accompanying list there is scarcely a species that does not furnish food for wildlife, and especially among the woody species there are many of outstanding value. The food use tabulated is based on records of the U.S. Fish and Wildlife Service and others, according to compilations by Van Dersal (1938 and 1940b) for woody plants, and by Graham for the grasses (1941a) and legumes (1941b), except the shrub lespedezas, the data for which are from Davison (1945). Where genus only is listed the number of birds and mammals represents food use for the genus as a whole, although not all United States species may have been planted for erosion control. The figures, even so, are suggestive of the wildlife value of the plants. It should be noted that cover value is not enumerated, although in many cases where food use is not high the cover value may be first rate, as happens with many of the tall grasses.

The use of vegetation—herbs, shrubs, vines, and trees—is important in gully stabilization, which can be accomplished by planting of seed or nursery-grown stock. Such revegetation of gullies provides an opportunity for the establishment of plants of value for wildlife, home fruit production, or some other special purpose. Gully stabilization can also be accomplished by allowing natural or volunteer plants to invade the area. If plant succession is depended upon, it is imperative that water be diverted from the gully, an expedient desirable in any event.

Whatever course is chosen for gully revegetation, it is highly important that the area be protected from fire and grazing. Again

TABLE 3. PLANTS MOST USED FOR EROSION CONTROL IN THE UNITED STATES

(Based on Soil Conservation Service Nursery Production Records)

PLANT	PRINCIPAL USE								WILDLIFE VALUE
WOODY	Range and Pasture	Waterways	Sand Binders	Windbreaks	Woodlands	Gullies	Streambanks	Field and Woodland Borders	Approximate Number of Birds and Mammals Known to Use the Plant for Food
Indigo bush (*Amorpha fruticosa*)				x					2
Saltbushes (*Atriplex spp.*)	x								30
Siberian peatree (*Caragana arborescens*) *				x					?
Catalpa (*Catalpa speciosa*)					x	x			1
Hackberry (*Celtis occidentalis*)				x					25
Dogwoods (*Cornus spp.*)				x		x		x	65
Scotch broom (*Cytisus scoparius*) *			x						2
Russian olive (*Elaeagnus angustifolia*) *				x	x	x			10
Eucalyptuses (*Eucalyptus spp.*) *				x	x				?
White ash (*Fraxinus americana*)				x	x				5
Green ash (*F. lanceolata*)				x					6
Honey locust (*Gleditsia triacanthos*)				x	x				6
Black walnut (*Juglans nigra*)					x				5
Red cedar (*Juniperus virginiana*)				x	x				55
Bicolor lespedeza (*Lespedeza bicolor*) *								x	5
Bush lespedeza (*L. cyrtobotrya*) *								x	5
Amur privet (*Ligustrum amurense*) *						x			?
Tuliptree (*Liriodendron tulipifera*)					x				7
Tatarian honeysuckle (*Lonicera tatarica*) *				x					?
Osage orange (*Maclura pomifera*)				x	x				3
Mulberries (*Morus spp.*)				x	x				30
Spruces (*Picea spp.*)				x	x				40
Pines (*Pinus spp.*)				x	x				70
Cottonwoods (*Populus spp.*)				x	x		x		20
American plum (*Prunus americana*)				x		x		x	1
Bessey cherry (*P. besseyi*)				x					1
Beach plum (*P. maritima*)				x					1
Douglas fir (*Pseudotsuga taxifolia*)					x				9
Oaks (*Quercus spp.*)					x				125
Black locust (*Robinia pseudoacacia*)				x	x	x			15
Willows (*Salix spp.*)			x			x	x		40
Coralberry (*Symphoricarpos orbiculatus*)						x		x	30
American elm (*Ulmus americana*)				x	x				8

TABLE 3. PLANTS MOST USED FOR EROSION CONTROL IN THE UNITED STATES (*Continued*)

(Based on Soil Conservation Service Nursery Production Records)

PLANT	PRINCIPAL USE								WILDLIFE VALUE
HERBACEOUS	Range and Pasture	Waterways	Sand Binders	Windbreaks	Woodlands	Gullies	Streambanks	Field and Woodland Borders	Approximate Number of Birds and Mammals Known to Use the Plant for Food
Crested wheat grass (*Agropyron cristatum*) *	x								?
Slender wheat grass (*A. pauciflorum*)	x								3
Western wheat grass (*A. smithii*)	x	x							3
Bluebunch wheat grass (*A. spicatum*)	x								1
European beach grass (*Ammophila arenaria*) *			x						?
American beach grass (*A. breviligulata*)			x						2
Big bluestem (*Andropogon furcatus*)	x								1
Sand bluestem (*A. hallii*)	x		x						?
Little bluestem (*A. scoparius*)	x								1
Side-oats grama (*Bouteloua curtipendula*)	x								?
Blue grama (*B. gracilis*)	x								3
Mountain brome (*Bromus carinatus*)	x								3
Buffalo grass (*Buchloë dactyloides*)	x								4
Bermuda grass (*Cynodon dactylon*) *	x	x							?
American dune grass (*Elymus mollis*)			x						2
Weeping love grass (*Eragrostis curvula*) *	x								?
Lehmann love grass (*E. lehmanniana*) *	x								?
Galleta (*Hilaria jamesii*)	x								1
Sericea lespedeza (*Lespedeza sericea*) *						x		x	4
Indian rice grass (*Oryzopsis hymenoides*)	x								3
Vine mesquite (*Panicum obtusum*)		x							2
Kikuyu grass (*Pennisetum clandestinum*) *		x				x			?
Kudzu (*Pueraria thunbergiana*) *	x	x				x			2
Sand dropseed (*Sporobolus cryptandrus*)	x		x						3

* Introduced species.

and again, in the establishment of land-use practices of value to wildlife, the first two rules turn out to be: (1) protection from fire; and (2) protection from livestock.

Odd Areas

The term 'odd area' is not very descriptive, but it has come into use in some quarters and has assumed a particular meaning. An odd area is an otherwise unclassified parcel of land such as a rocky knoll, outcrop, escarpment, field corner, sand blowout, highly alkaline area, small box canyon, or rock pile. It is any miscellaneous area that has as its best use the production of a wild plant or animal crop. It might also be called a wildlife island, an odd spot, or a wildlife area.

Agricultural land has a great many odd areas. They are generally ignored in systems of land classification and are usually regarded as wasteland. Unlike the other land areas discussed in this book, not much in the way of special treatments has been developed for odd areas. This is because they do not present critical land-use problems, and ordinarily do not require specific attention, such as the establishment of particular kinds of vegetation. They can be made more beneficial to wildlife, however, by thoughtful consideration (Plate 18).

Because a great many kinds of upland game birds and mammals, as well as furbearers and other useful wild creatures, require well-distributed cover, the odd area has a place in land-use programs beneficial to wildlife. Like the windbreak, hedge, field border, vegetated ditch or streambank, and protected roadside, odd areas provide wildlife food and shelter, often in strategic positions scattered in crop fields, pastures, or range land. They render much surrounding land potentially valuable, which might otherwise be of little benefit to wild animals. An open, uninterrupted field may fail to support a single bobwhite, but if a rough area covered with shrubs and vines occurs near the center of such a field, it may become suitable habitat for a covey of quail.

The practices in this book are advanced with a view toward the time when every parcel of land will be managed in accordance with its best use. This time may be far away, but every year more

and more land is so managed. Many individual farms and ranches already are run that way. If the wildlife manager achieves his purpose through proper land use, no acre will be used exclusively for wildlife if it can properly be used to produce tilled crops, livestock, or timber. If a parcel of land is best adapted to wildlife, on the other hand, such use should not be neglected.

Even in the most intensively used and scientifically directed system of managing land, the odd area will occur. It is too small to produce timber or support pasture, and it is too rough, stony, infertile, or otherwise unsuited for crop production. The land operator wastes labor, time, seed, fertilizer, and the land itself if he tries to do anything with the odd area other than render it most productive of whatever crops it can naturally yield. These crops are wildlife and associated products, such as honey-bee pasturage and fruits for home use.

Although odd areas, like gullies, may be planted, most of them are already well vegetated. In some regions land operators with a special interest in wildlife are planting odd areas to evergreens for winter cover and to food-bearing shrubs. As with gullies, the primary rule for managing odd areas is to protect them from fire and grazing.

Spoilbanks

A spoilbank is exposed earth, usually consisting of parent material turned up by digging ditches or surface mining. Inasmuch as ditchbanks are treated elsewhere, this section deals largely with exposed earth resulting from strip or surface mining. It is difficult to generalize with respect to strip-mine treatment, just as it is with other land treatment. If conditions in a particular place are selected for consideration, however, we can view the problem.

In Ohio it is apparent that two or three general conditions prevail. According to Chapman (1944), the western half of the state and the northernmost counties are covered with a glacial till so deep that strip mining leaves spoilbanks composed entirely

or primarily of disturbed glaciated material. Long weathering is not required to render these areas habitable to plants. Owing to the texture and fertility of the glacial mantle, spoilbanks composed of it begin to revegetate soon after they are made. Southeastern Ohio, on the other hand, is an area of unglaciated soils, where stripped areas leave spoilbanks containing a high percentage of limestones and limey shales. Coarse rocks and other heavy materials of this sort require a long period of weathering before they can support many plants. Between these two areas there is an unglaciated belt of sandstones and acid shales, somewhat intermediate in physical and chemical properties.

Since 1920, about 150,000 acres of land in the United States have been strip-mined, chiefly for coal. In Ohio alone 9000 acres of land have been mined for coal by the stripping method. In recent years there has been an increase in the extent of mining by this process, and a great deal of time and attention has been given to the revegetation of spoilbanks resulting from it. Most of such effort has consisted of planting trees. Although various counts have shown good survival, even among certain hardwoods, such as green ash, red oak, and silver maple, growth rate is very slow, and after many years does not provide suitable ground cover. Pines often grow fairly well but do not produce much leaf litter. The only tree that seems worth planting is black locust, for in spite of damage from locust borer, it grows reasonably well and is considered a good site conditioner. Moreover, black locust is a natural pioneer in the regions where most spoilbank revegetation has been attempted.

This brings us to a consideration of the revegetation of spoilbanks by natural methods or by types of treatment in close harmony with nature. Such approach may provide results more rapidly and economically than any other. What should be done to rehabilitate spoilbanks resulting from strip mining of coal and other minerals? The answer might best be determined by appraising: (1) what nature does to spoilbanks; (2) what spoilbanks are

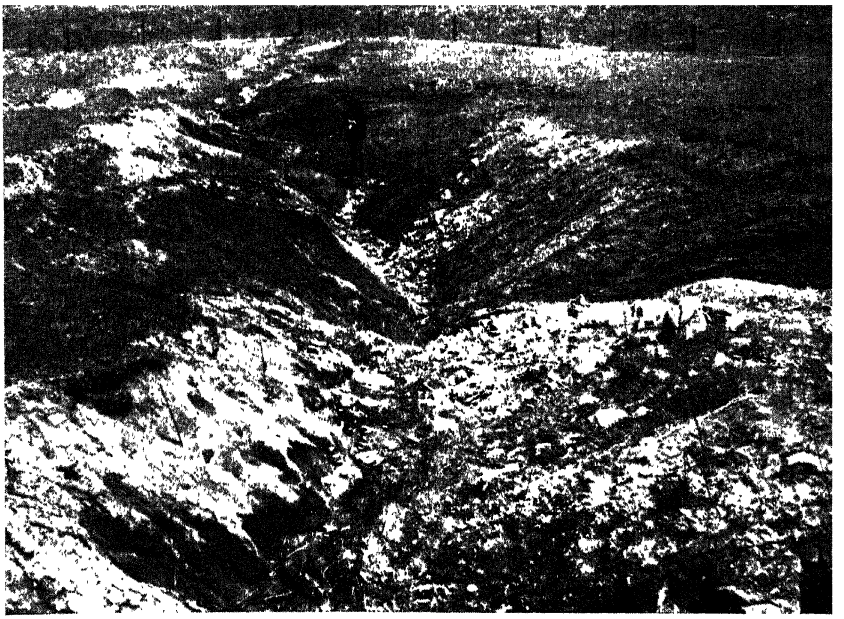


PLATE 17: TOP. A gully in an Ohio field planted to black locust and cottonwood. BOTTOM. Four years later the same gully is protected from erosion and provides a shelter for birds and mammals.

PLATE 18: TOP. The odd area protected from ax, fire, and livestock makes a productive parcel of wildlife land.

BOTTOM. The cottontail rabbit, many furbearers, and game and insectivorous birds live in odd areas.

PLATE 19: TOP. Land strip-mined for coal in Ohio was planted with black locust. BOTTOM. The same area seven years later has cover enough to make a good game and furbearer habitat.

PLATE 20: TOP. Conservation farming protects the soil, increases crop yields and benefits wildlife.

BOTTOM. Hunting rabbits for sport (left) or trapping them for stew depend upon the way the land is used.

PLATE 21: TOP. Well-vegetated pastures take their place among land-use measures contributing to wildlife conservation.

BOTTOM. The groundhog is sometimes unwanted but his burrows may influence abundance of cottontails.

PLATE 22: TOP. Uncontrolled fire is an enemy of the forest and the wild creatures that dwell there.

BOTTOM. Grazing of farm woodlands (left of fence) lowers yields of wood products and of wildlife.

PLATE 23: TOP. Eroded field in Minnesota planted to trees and shrubs.
BOTTOM. Four years later there is a promising young woodlot furnishing soil protection and a place for wildlife.

PLATE 24: TOP. The moose is characteristic of American wilderness wildlife. BOTTOM. The wild turkey (left) and black bear are denizens of American forests.

capable of producing; and (3) what it is profitable to do with them.

WHAT NATURE DOES TO SPOILBANKS

Examination of untreated spoilbanks in southeastern Ohio reveals that those respectively one, three, five, ten, and twenty years old are each covered by a different kind of vegetation. Furthermore, the same type of plant cover is found on different banks of similar ages.

Spoilbanks a year old, where very little weathering of the overturned earth has taken place, support only a sparse cover of annual weeds. On banks about three years old, perennial weeds such as aster and goldenrod are most abundant. Canada bluegrass and other perennial grasses then appear until, about the fifth year, the plant cover consists of grasses with a mixture of other perennial plants. Slowly this cover changes until, after ten years have elapsed, a few woody shrubs and a tree species or two have appeared. A typical ten-year-old spoilbank in southeastern Ohio is fairly well covered with grass, aster, goldenrod, wild carrot, thistle, blackberry, Indian hemp, elderberry, young cherry, and black locust.

Given another ten years the aspect of the bank is still different, although changes then occur less rapidly. The earlier plants have resulted in a lowering of the soil temperature. Their roots and leaf mulch, together with the soil micro-organisms that have come to live with them, have disintegrated the surface layers, and the entire bank has settled and weathered considerably. Thus, at twenty years, locust trees up to eight inches in diameter, an undergrowth of grasses and herbaceous perennials, together with shrubs such as sumac, elderberry, and blackberry, cover the slopes. Many young elms and cherries, as well as scattered trees of maple, ash, aspen, catalpa, and sycamore also occur and indicate the type of woodland that will come to occupy the area with the succeeding years.

These changes are not accidental or haphazard; they represent

an exacting process in nature as inviolate, in its way, as reactions of chemical substances. They may, like a chemical equation, be diagramed thus:

annual weeds ⟶ perennial weeds ⟶ grasses ⟶ shrubs ⟶ trees

Local conditions cause variations of this equation, but the trend remains unchanged.

On sites where calcareous strata overlay the coal, and the surface of the spoilbank is consequently rather rich in calcium with fair amounts of phosphorus and potash, sweetclover—a biennial that often reseeds itself—may volunteer, to shorten the transition from the annual weed stage to grasses. On slopes that are exposed to the southwest, soil temperatures may remain so high during the growing season that seedlings have little chance to survive. Southwest slopes twenty years old may remain bare, while the remainder of the area is vegetated with plants in the late-shrub or early-tree stages. Whatever the local variations, however, the progression of plant growth on spoilbanks, as on other bare areas, is according to natural law, and man does best to lay his plans accordingly.

In the depressions between the ridges of spoilbanks, water frequently collects, forming long narrow ponds. Under some conditions the pond water may be toxic, although about half the ponds on eastern Ohio strip-mined areas are fit for fish production. In the water a process takes place similar to the revegetation of the spoilbanks themselves. Among the early plants to invade the ponds is the cattail, which rapidly establishes itself along the shores where the water is less than three feet deep, usually within two to three years. Small submerged plants, many microscopic in size, also grow in the water. As vegetation clothes the disturbed earth and weathering continues, the slopes become richer in organic matter and micro-organisms, and the drainage from the slopes slowly improves conditions for plant life, and so for fish, in the pond waters.

WHAT SPOILBANKS ARE CAPABLE OF PRODUCING

Reference to schemes of land classification can help to evaluate treatment of spoilbanks, as it can of other areas. A classification according to land capabilities, developed by the Soil Conservation Service, indicates the best use of a parcel of land through consideration of soil type, slope, degree of erosion, and other physical factors (Hockensmith and Steel 1943). The classification arbitrarily grades land from Class I through Class VIII. Other systems may recognize more or fewer classes, but this one serves to illustrate the contribution of land classification as an aid in determining use.

Land classes I to IV are suitable for cultivation with the application, in varying degrees of intensity, of special practices for conserving the soil.

Classes V to VII are not suitable for cultivation even with the use of complex soil-saving practices. They are suitable for grazing or woodland use under certain conditions.

Class VIII is unsuitable for cultivation, grazing, or woodland use, but is useful for wildlife and for its recreational and aesthetic values. It is described as land that is usually productive of useful wild plants, furbearers, game and insectivorous birds, and fish, and usually serves as wild-animal range. Many, but not all, of the areas treated in this book represent Class VIII land.

Spoilbanks in Ohio, as in other areas, are accordingly classified as Class VIII or, occasionally, as Class VII land. All banks in Guernsey and Muskingum Counties, for instance, are considered to be Class VIII lands; those in other eastern Ohio counties are either Class VIII or Class VII, depending upon whether the banks are believed capable of producing pasture grasses or tree crops (Whiteford *et al.* 1944).

Class VII land may be developed as pasture only under particular conditions, and if trees are to be grown, sites and species should be selected as pointed out below. Class VIII spoilbanks are

best managed with the development of wildlife and recreation as the ultimate objective. Wildlife use involves the development of the banks themselves as a home for quail, pheasants, rabbits, squirrels, raccoons, opossums, and other birds and mammals, together with the management of the ponds for fish, muskrats, and mink. Strip-mined areas several years old usually produce wildlife in such abundance that they provide a great deal of hunting and considerable fishing. In many places strip-mined areas that have become naturally covered with trees are ideal spots for picnicking, and the ponds are utilized for boating.

WHAT IT IS PROFITABLE TO DO WITH SPOILBANKS

It should be borne in mind that much land that has been stripped for coal was worth comparatively little for agricultural purposes prior to stripping, and that it would require many, many years, sometimes centuries, of the most intensive use to equal, in agricultural crops, the value of the coal produced from such lands. Furthermore, in a few decades or less following mining operations a useful return from fruits and berries, wildlife, and recreation can be realized on coal-stripped lands. Under unusually favorable conditions, they may support woodland or pasture. Funds to be expended on the rehabilitation of spoilbanks should be related to the most desirable future use to be made of them (Plate 19).

Establishment of pasture should be attempted only on banks that are calcareous and not too steep or rocky. On such sites pasture mixtures of adapted plants such as bluegrass, lespedeza, sweetclover, and true clovers might be seeded successfully. Grazing should be adequately controlled so as to retain a good grass cover, for mowing and fertilizing as pasture-management measures are physically difficult to apply and economically unprofitable on most spoilbank sites.

In attempts to make good use of spoilbank areas, several states have passed laws requiring strip-mine operators to plant trees on

the banks when operations are completed. A fine is levied by some states for failure to do such planting. Because the penalty is often less than the cost of establishing the trees, many companies prefer to pay the fine. Others, however, have made conscientious efforts to plant both hardwoods and pines, and are desirous of doing what they can to treat the land that has been disturbed. There has been some discussion about requiring operators to level spoilbanks when mining is finished, but less has been done on this score than on demands for planting.

Most hardwood trees belong to an advanced stage of plant succession, and are not likely to succeed when planted on spoilbanks less than twenty years old. Until mulch from other plants and weathering have prepared the soil for them, it is inadvisable to plant such trees as oaks, hickories, and walnuts. Although black locust is a natural invader, on poor sites it is subject to considerable damage by the locust borer. Borer damage is known to be related to site condition, and to be most damaging on the most depleted soils.

Pines and red cedar will grow on dry, warm, infertile soils, and have succeeded on spoilbanks. But young seedlings of these conifers do not grow well, three- to four-year stock once transplanted in the nursery being required. It is questionable whether the rate of growth and the cost can justify the use of nursery-grown stock. Pines make their best growth at the base of spoilbanks, or on the outside slope, where considerable soil is mixed in the bank. Pines thus grow best where they are useful in screening the banks from roads or hiding them from surrounding occupied lands.

The least expensive treatment and the most rapid return on strip-mined acres can be realized by devoting their use to wildlife and recreation. This type of management rests primarily upon natural revegetation of the banks. Strip-mined areas become refuges for cottontails, pheasants, and other kinds of wildlife within a very few years. As time goes on, given reasonable protection from grazing and fire, they become more and more suitable

for various wild animals until, with the development of trees, even squirrels and other woodland species find homes there. Old spoilbanks are ideal habitats for furbearers, and they provide first-class trapping areas for skunk, raccoon, opossum, and muskrat.

The chief practicable measure with respect to the artificial improvement of coal-stripped lands as wildlife habitats would be the establishment of plants that might accelerate the process of succession. It should be remembered, however, that such 'acceleration' is both difficult and costly. It can be done only within limits, for, as mentioned above, it is not possible rapidly to convert the weed cover into a good stand of trees.

As a means of benefiting wildlife habitat and of improving soil conditions, it would seem most feasible to employ plants belonging to the late grass or shrub stage in order to reduce the time naturally elapsing between the invasion of weeds and the establishment of trees. The plants used should be of species that can be seeded directly, perhaps under a light mulch, thus eliminating the use of expensive nursery-grown stock. Examples of species that show promise of most success in Ohio and comparable areas are the following:

Shrubs:

Multiflora rose (*Rosa multiflora*). A vigorous, thorny, white-flowered shrub 6 to 8 feet tall.

Sand cherry (*Prunus besseyi*). A small bushy shrub, with edible fruits.

Perennial legumes:

Juncea lespedeza (*Lespedeza juncea*). A bushy perennial 2 to 3 feet tall.

Shrub lespedezas (*Lespedeza bicolor* or *L. cyrtobotrya*). Woody shrubs 4 to 6 feet tall. Direct seeding of *Lespedeza bicolor*, without site preparation, has provided desirable stands in two years' time on strip-mine spoilbanks in Pennsylvania.

Kudzu (*Pueraria thunbergiana*). A herbaceous plant with woody rootstocks, to be propagated from nursery-grown crowns, not seeds. Best south of Mason-Dixon line.

Indigo bush (*Amorpha fruticosa*). A woody shrub up to 12 feet tall.

Scotch broom (*Cytisus scoparius*). A woody shrub 6 to 10 feet tall.

Perennial grasses:

Switch grass (*Panicum virgatum*). Grows in large bunches, the flowering stems 3 to 6 feet tall.

Love grass (*Eragrostis curvula*). Grows in dense bunches, the slender drooping leaves in large dense clumps 1 to 2 feet tall.

Little bluestem (*Andropogon scoparius*). Grows in small tufts, the flowering stems 1 to 3 feet tall.

Tall oat grass (*Arrhenatherum elatius*). Tufted, up to 4 feet tall.

Ponds on strip-mined areas can be expected to produce high yields of fish if some attention is given to stocking them with appropriate species and to artificial fertilization of the water. The large size of some strip-mined ponds makes them particularly well adapted to community, club, or even commercial fishing. Their management for muskrat production is also profitable, as shown by experience not only in Ohio but in strip-mined areas in other states. So spoilbank ponds can contribute fish and furbearers for recreation and financial profit.

In summary, at least for conditions in many eastern states, it may be stated that:

1. The most profitable use of spoilbanks is considered to be recreation and wildlife production.

2. Efforts at rehabilitation should be correlated with natural processes.

3. Pasture should be developed only under very favorable conditions, as where slope is slight, banks are not composed of large rocks, and the material is somewhat calcareous.

4. Woodland trees of hardwood species should not be planted until the banks have been weathered and otherwise conditioned for a decade or two. Pines and other conifers can usually be

planted sooner and are utilized most profitably where there is some surface soil mixed with the spoilbank material.

5. Wildlife and recreational use is accomplished largely by natural revegetation of the banks, together with their protection from fire and grazing, and management of the ponds for fish and furbearers.

6. To assist in improving soil and hastening revegetation, seeding of shrubs, woody legumes, and bunch grasses gives most promise on banks that have been weathered and otherwise conditioned for a few years.

X ⇛ CROPLAND, PASTURE, AND WOODLOT

Cropland

At first thought there may seem to be no type of land with which the wildlife manager has less reason to be interested than cropland. The field of corn, cotton, beans, or potatoes—clean cultivated and re-established each year—would seem to present a poor place for wildlife. Yet no part of an environment can properly be appraised except in its relation to other parts. Many of the practices already discussed help immeasureably to improve the value of crop fields as wildlife habitat. The revegetated gully, the odd area, the field border, the hedge, the managed ditch or streambank that cuts across cropland—all these add a wildlife bounty to the aggregate returns from land used for cultivated crops.

The thesis that land-management practices likely to remain permanent features of the land pattern are the only ones worth the whole-hearted support of the wildlife manager is well illustrated on cropland. Cropland is intensively used for cultivated crops. One cannot invoke intensive management for cultivated crops and for wildlife on the same parcels of land. Farmers must give first attention to efficient and productive handling of field crops. They cannot allow anything to interfere with this primary purpose.

From a land-use standpoint the much-heralded food patch can never be more than a subsidized feature of wildlife management on cultivated land. The patch of corn, sorghum, millet, sunflower,

and other grains often encouraged for the corner or margin of a crop field is a stopgap measure. It is so for two specific reasons. First, the food patch requires re-establishment each year, because the plants that compose it are annuals that do not reseed themselves. Yearly establishment of the food patch demands time, effort, and expense that the land operator can invest better by growing a crop for his own use. The second reason that food patches are impractical relates to the land itself, for the land upon which such plants are established is not wildlife land; it is cropland. There is no practical justification for devoting to wildlife use much, if any, of the land that is suited to the production of cultivated crops. Food-patch plants are in fact crop plants; they demand land of highest quality.

There is involved in this matter of food patches a point of considerable importance, for it is often argued that the better the land, the better the wildlife it sustains. And so it may be. Pressure of human population will eventually demand that each kind of land be put to the most intensive, productive use of which it is permanently capable. Modified by economic and social exigencies, this is a guiding principle in land management, and one that is ecologically sound. Therefore, land capable of growing cultivated crops year after year without deterioration must be used to that end. Land less capable of such intensive treatment must be carefully maintained in pasture and range, woodland or forest. And land not adapted for one reason or another to any of these purposes will be the land used for wildlife.

This view has been criticized by wildlife managers because it intimates that the only land that will be used to produce wildlife is land that is good for nothing else. Even if this were so, the conclusion could not easily be escaped. Man, not unlike wildlife, must first of all have food, and he must get it from the land. Let us remind ourselves, however, that there is a very considerable amount of land suited only to wildlife production—in the United States a total of 100 million acres. Proper treatment of this land —five per cent of the land acreage of the country—can well chal-

lenge the ingenuity, resourcefulness, and labor of wildlife managers for a long time to come. Productive management of this land depends primarily upon the development of practical land-use measures by those interested in yields of wild plant and animal crops.

The wildlife managers need not consider their concern with land to end with the management of these 100 million acres. For techniques dealing with those acres the land-use biologist has the primary technical responsibility, as the agronomist has with cropland, and the forester with the woods. But for every type of land, the wildlife manager has a real and important responsibility. This is well illustrated by the things that can be done to make croplands productive of wildlife. The land practices discussed in preceding chapters—gully treatment, field-border plantings, hedges, windbreaks, streambank revegetation—are fundamental factors in rendering crop fields productive of wildlife. Such practices, in fact, combined with cultivated fields, create some of the best of modern wildlife habitats. Quail, pheasants, rabbits, and many other valuable upland game, as well as insectivorous and fur-bearing species, thrive in cultivated land punctuated by the cover types made possible by the land-use practices described.

It is well to mention the influence upon wildlife of land-management practices that in themselves are not aimed at benefiting wildlife. An outstanding example on cropland is strip cropping, a scheme of management directed at checking the flow of runoff water across long slopes, in order to reduce accelerated soil erosion (Plate 20). The strips vary in width, are placed on the contour, and form alternating bands of a clean-tilled crop like corn, with a strip of meadow or close-growing crop like alfalfa. The crops are rotated from year to year within the strip pattern, but always present alternating bands of adjacent tilled and non-tilled crops.

At first glance, strip cropping may seem to offer no advantage to wildlife, but studies (Dambach and Good 1940) have shown that it does. A strip-cropped field of corn, grain, and meadow harbors about twice the number of ground-nesting birds to be

found in a comparable field planted solidly to meadow, even though the stripped field has less acreage planted to the meadow crop. Whether this results from increased proximity of food and cover, some unknown effect of interspersion of cover types, increase of territory because of the breaking up of the meadow areas, or to something else, is not altogether clear. Whatever the reason, strip-cropping reminds us once again that good land management may be the key to the best wildlife management. It also shows that the wildlife manager has a vital concern with land even when it is as intensively managed for other purposes, as are cultivated fields.

It is probably no exaggeration to state that every single measure intended for erosion control on cropland has some wildlife value. In addition to the practices already mentioned, there is value to wildlife in grassed waterways, vegetated diversion ditches, green manure and cover crops, and other agronomic practices that place vegetative cover on the land—cover useful in holding soil and providing a bit of extra shelter and food for wild birds and mammals. Contour cultivation, crop-residue management, subsoiling, and similar practices at first seemingly far removed from wild creatures do their part, for any soil- and water-conservation practice that reduces the amount of silt in streams is in itself a factor in the management of aquatic wildlife. It is not difficult to agree with H. H. Bennett (1944) when he states that he 'could go through the whole list of fifty-nine land-use measures which we employ in our nationwide program of soil conservation, and I believe that every one of them would show some benefit to wildlife.'

Pasture

The best practice for producing wildlife on land devoted to pasture is good pasture management. Like crop fields, pastures are of benefit to wildlife largely by the variety they lend the land pattern, providing grassy areas usually intermingled with crop fields and woodlands. Some animals make their homes in the

cover of good pastures, where the turf remains unimpaired and the grasses are thick and vigorous (Plate 21).

The number of ground-nesting birds is higher in pastures than in ordinary crop fields. Strip-cropped fields, however, support more birds than pastures do. In meadow strips, according to a recent Ohio study (Good & Dambach 1943), there were 74 breeding pairs of birds, such as meadowlarks and grasshopper sparrows, for every 100 acres. In pastures there were 64 pairs per 100 acres. The same study shows that management that allows good plant cover increases the number of birds nesting in pasture areas.

A simple pasture-management measure beneficial to wildlife is rotation grazing. By this practice, pasture land is divided into a number of fenced units, only some of which are used at any one time. The units are grazed in orderly sequence, sometimes in seasonal, sometimes in yearly, rotation. Such procedure permits a taller growth of grass while it is ungrazed, and corresponding benefit to ground-nesting birds.

A word about meadows is appropriate at this point. Meadows differ from pastures in that they are not grazed, but the plants composing them are mowed for hay, which is later fed to livestock. As with pastures, the better the growth of the meadow plants the better cover there is for ground-nesting birds. Pastures are sometimes mowed to control weeds. This is done by setting the cutting bar high enough to avoid cutting the grasses, but not so high as to miss the weeds which usually overtop the grasses. The weeds are cut before they go to seed. This cutting disturbs ground-nesting birds less than the closer cutting for hay, which in most regions occurs after nesting is over.

In order to avoid injury to birds nesting in meadows, wildlife managers sometimes recommend a device known as the flushing bar. The flushing bar is a pole or rod with strings or streamers of some kind suspended from it. It is usually attached to the mowing machine ahead of the cutting bar. Its purpose is to flush ground-nesting birds and permit the operator of the mower to raise the cutting bar and preserve a patch of grass around the nest.

The flushing bar is a good example of the kind of artificial wildlife management that has too frequently been advised for agricultural lands. Like the food patch and winter feeding, it is a cure to which we finally resort when we have missed something that is fundamentally wrong. We should not have to depend upon gadgets to produce wildlife. If the land is in good shape—if the meadows and pastures are well grassed—they will support a population of birds not likely to feel the effect of occasional mortality from mowing machines. The average farmer, for practical reasons, will not long put up with such tricks anyway, as experience has abundantly proved, and unless the wildlife-management measures he undertakes become part and parcel of his normal land-use operations, they are doomed to failure.

Modern conservation farming has another element of advantage to wildlife. The advantage comes from the adjustments often required to insure use of the land in accordance with its physical capabilities. If corn or other cultivated crops are being grown upon slopes where erosion cannot be controlled under such use, the slopes are often converted to pasture, meadow, or woodland. During the past eight years farmers and ranchers in soil-conservation districts, as a result of conservation farming, have converted two and one-half million acres of croplands to some other use. The total improvement of conditions for wildlife, resulting from such land-use adjustments, is a material one.

Woodlot

The management of the farm woodlot for the sustained yield of wood products contributes greatly to wildlife welfare. Reduced to simple terms, good woodlot management can be summarized in three rules: (1) Protection from fire; (2) protection from grazing; and (3) selective cutting. Although it is true that in some areas fire is profitably employed as a tool in woodland management, as in the longleaf pinelands of the eastern Gulf Coast, such burning is of a special sort, carefully controlled. In other

places, it may be argued, there is no harm in lightly grazing woodlots. Generally speaking, however, the farm woodlot unquestionably is better managed when fire and livestock are excluded (Plate 22). Both fire and grazing are damaging to young trees, destructive of the woodland carpet, often disturbing to the soil beneath. In so far as wildlife is concerned, it would be difficult to find management measures more permanently useful than the elimination of the destructive influences of uncontrolled burning and promiscuous grazing.

The third rule of woodlot management—to cut selectively—is also of great value to wildlife. To cut selectively means to cut trees as they mature—here and there throughout the woods—instead of cutting the whole lot at once, as is so often done. When wholesale or clear cutting is employed, a woodlot becomes devoid of large trees, and young growth is so disturbed that a long time is required to restore true woodland conditions. Areas clear cut are easily turned to pasture or even cleared for cultivation, thus losing the woodlot completely. Careful cutting of mature trees only, on the other hand, preserves the woodlot as a permanently productive part of the farm plan and economy.

As large 'ripe' trees are felled by selective harvesting, the woodlot is opened here and there to permit the growth of younger trees. Such practice adds variety to the pattern of the woods and to the kinds of wild creatures inhabiting them. Shrubs and herbs, as well as young trees, thrive in these openings, and this variety in itself is productive of more woodland wildlife than is a stand of uniform age. For woodland products alone, diversity within the woodland is desirable, but, as noted above, selective cutting also preserves the woodlot as a habitat for birds and mammals different from those to be found in the surrounding pastures and croplands.

Studies support these principles. A recent investigation comparing protected and unprotected Ohio woodlots, for example, shows the decided advantage to both the woodlot and to wildlife as a result of protecting the woods from grazing (Dambach 1944).

At the beginning of the study both woodland plots were grazed so severely that tree seedlings could not become established, and only scattered, deformed, herbaceous plants were to be found. In the portion of the woods in which livestock was then excluded, seedling trees became established in abundance the third year following protection. Almost all of the young trees were sugar maples, the dominant mature species in the woodlots. In the immediately adjacent grazed woods no seedling trees became established, although thousands of seeds germinated every year. At the end of the ten-year period, herbs and shrubs occurred to the number of 124 species in the ungrazed woods. In the grazed woods only 61 species could be found, and these were sparsely represented by stunted individuals. There was also a much heavier leaf litter on the floor of the protected woodlot.

What of wildlife in these woods? A five-year evaluation of birds showed them to be four times as abundant in the ungrazed area. In the ungrazed woods, 40 per cent of the kinds and 60 per cent of the individuals nested in shrubs or on the ground; only 27 per cent of the birds—kinds and numbers—in the grazed woods could find nesting havens in shrubs or on the ground. Mammals were also more numerous in the ungrazed woods, which supported 81 mammals per acre. In the grazed woods there were 49 mammals per acre. In the ungrazed area, 14 species of mammals occurred; in the grazed area, 12. Other differences in the two woodlots were recorded. It may be said on the basis of studies such as this that the woodlot from which grazing is excluded is not only a better woods, it is about twice as productive of wildlife.

In support of the theme of this book, it is of considerable moment to refer to a recent work on the fox squirrel in Michigan, which indicates that good land management throughout a watershed can contribute to the welfare of a woodland species. The author of this work, Durward L. Allen (1943), relates the regulation and utilization of the fox squirrel to land use, both past and present. He points out that in the original land surveys of Mich-

igan, as in most other states, townships and farms were laid out with straight boundary lines usually parallel and perpendicular to each other, more or less regardless of topography. In consequence, farmers laid out rectangular fields, and a plot, perhaps of 10 acres, would be left in woodland, whether it was level and tillable or not. Another plot would be cleared and cultivated, even if it included steep or rough land. The pattern of the farm resulted more from circumstance than design, and much land was misused and ultimately damaged.

Contrasted with the old method, Allen points to modern soil-conservation farming, with contour cultivation, strip cropping, land conversions, and related practices, as a type of agriculture fitted to natural topographic features and the demands of the environment (Plate 23). He considers modern farming to be one of the most important influences in squirrel management, and writes:

> This trend in agriculture has been stressed because it is fundamental to the entire game management program in southern Michigan. . . It should be quite evident that a modernized farm is a better fox squirrel habitat than one operated under old methods.
>
> The principal reason for this is the increase in edge. Contoured pastures and woodlots are irregular in shape, and strip-cropped fields present a large extent of borderline between different kinds of cover. On many areas woodlot sites will vary from the highest uplands down to the stream-bottoms. These will support that variety of tree growth which gives the fox squirrel a more dependable food supply. In croplands small gullies and waterways are in sod and brushy escape cover. These further break up the pattern, furnish various fruits and seeds, and provide small 'waste' areas where nut trees can grow.
>
> From the standpoint of squirrel management, the most promising condition on a modernized farm is the size and shape of woodlots. In principle, areas not suitable for more valuable crops should be devoted to trees. This will locate many woodlots on the sides of narrow slopes and in small units. Such woodlands have extensive borderlines, and much larger mast crops can be

expected than if they were solidly blocked. Such tree growth also forms excellent communication lines. From what has been learned at Rose Lake [Wildlife Experiment Station] and elsewhere, hilly land managed according to the best soil conservation and agricultural practices approaches closely the most up-to-date ideas of what a good farm wildlife habitat should be. And the idea applies particularly to the fox squirrel.

In addition to the three rules already advanced, it should be pointed out that there is another modern land-use practice of value both to wildlife and woodlands. It is the field border described in Chapter VII. Considered primarily as a practice applicable to fields, or to field margins, the establishment of desired vegetation where crop fields and woodlots meet is important with respect to woods as well as to crop field. Wildlife is found there and the border planting, especially of shrubs, is as much a part of the woodlot as the trees. No planting of trees for a new woodlot is complete, in fact, unless a border of appropriate shrubs surrounds it. Borders give value to the woods by the protection afforded against desiccating and otherwise damaging winds. They are of value too in the control of trees likely to spread into the field. And protective cover is given to an area that often erodes.

Although the artificial feeding of wildlife is not confined to woodlots, a great deal of it is done in wooded areas on agricultural land. This is, therefore, an appropriate place to mention the subject. Like many other things encouraged by public-spirited groups, the distribution of grain, placing of ears of corn, and erection of shelters where birds and mammals can obtain feed in wintertime are activities well inspired though poorly proved. The actual effect of such activity upon the survival of wild animals is likely to be nil. Thoroughly scientific studies on the bobwhite quail and some other species reveal that the chief influence upon the number of birds surviving a winter is the condition of the habitat. This is not easily influenced by occasional provision of food in amounts, kinds, and locations chosen at random by a few sympathetic humans.

A comprehensive study of winter feeding and a review of pertinent literature was recently completed by a qualified wildlife technician (Gerstell 1942). After careful analysis of all the evidence at hand, the following conclusion was developed:

Study of the recorded winter losses of wildlife has clearly shown that in the northern United States and Southern Canada, which is the region wherein the largest winter feeding campaigns are annually conducted, severe mortality from starvation is commonly encountered only among bobwhite quail. Even with this particular species, exposure, or exposure in combination with food shortages, doubtless causes far greater decimation than starvation, as is the case with most other avian forms. Also, the controlled experiments previously described and discussed indicate that, with the exception of the bobwhite, most forms can readily endure with few, if any, serious ill-effects those periods of food shortage and exposure normally accompanying winters of all but the greatest severity. The tests have further shown that constant supplies of grit are not essential to wintering game birds, while even appreciable losses in body weight brought about by exposure and shortages of high quality foods, do not necessarily react unfavorably on fecundity during the breeding season immediately following. In view of these facts, there appears to be, except on very rare occasions, no actual need for furnishing wild birds and mammals with supplemental food supplies during the winter months, or in other words, for winter feeding.

It is well to recall that attempts to feed big game in the West, where it has reached large numbers, have shown no better results. Feeding hay to elk and deer in winter when they come down out of the mountains has not been of value in alleviating abnormal death losses.

It is difficult to distinguish between woodlots and forests, except by size of area and the fact that woodlots are essentially a part of a predominantly farming enterprise. Likewise, it is difficult to differentiate pasture from range, although we usually think of pastures as composed of artificially established grasses and leg-

umes, while range land consists of stands of native grasses, shrubs, or other indigenous vegetation. In so far as wildlife is concerned, there is greater variation between values and treatment of pasture and range than there is between woodlot and forest. The welfare of wildlife as influenced by the management of land devoted primarily to forests and range is the subject of the next chapter.

XI ⇛ FORESTS AND RANGE

Forests

Probably no phase of wildlife management has received more study than that which deals with the relation between forested land and wild animals. It is easy to assume that in the depths of the vast forests wildlife of all kinds finds refuge and can live unmolested forever. Perhaps this assumption has been in part responsible for the widespread interest in forest animals. Although our forests remain on the whole much less disturbed than our extensive range lands or the areas devoted to cultivated crops, most of them have been logged, burned, grazed, and eroded.

As a matter of fact, we must acknowledge that there is scarcely any of our 375 million acres of forested land in America today that has not in some way been modified by man. A large proportion of it has been cut over, usually by clear-cutting great areas and leaving them to recover without care. Much of it, especially logged-off areas, has subsequently been burned, often allowed to erode seriously. Even the forests that have escaped the axe and flame are commonly grazed by domestic livestock. Grazing is so heavy, especially in the mountainous regions of our western forests, that severe soil erosion has resulted. Our forests, we must acknowledge, are not undisturbed sanctuaries to which wildlife can retreat. Forests are subject to use, as are all our natural resources, and their use is likely in the future to be as intensive as good management will permit.

Even were our forests undisturbed, they could support only the kinds of wildlife adapted to forest conditions. It would be as incongruous to expect to find ring-necked pheasants, scaled quail, or muskrats as regular inhabitants of large forests as it would be to find martens and black bears making their homes in cultivated areas (Plate 24). We can expect considerable wildlife in forests, but, as with every other type of land, that wildlife will be determined largely by: (1) the kinds of wild animals inherently adapted to the environmental conditions the land supports; and (2) the use to which the land is put. A volume could be written on the management of forest wildlife as related to use of forest land. In this book we can only touch lightly on the matter.

It is usually impractical to recommend special forest-management measures merely because they may possibly have some value for wildlife. After it is determined that a given area is to be permanently maintained in a particular forest type, encouragement should be accorded to the wildlife normally to be expected in that type of forest. The wildlife characteristic of a successional stage, through which the forest must develop to reach the final type desired, should be recognized as transient, and efforts should not be made to perpetuate it in the face of a changing environment.

The Virginia deer of the Northeast is a pertinent example. It has occurred in great abundance only since the cutting of the original timber. This widespread occurrence was due in large part to brush which grew up in the logged-off areas. The brush provided deer with food. While the brush thrived, the deer thrived. As the brush matures into a type of woodland more like the original, the dense, shaded forest no longer permits open brushy tracts except in occasional burns, windfalls, or open areas caused by other natural disturbance. As the brush decreases, the deer decrease also.

An analysis of the white-tailed deer in Vermont has shown plainly the dependence of deer numbers upon the use that is made of the land. Leonard E. Foote (1945), who conducted the

study, points out that the number of deer in Vermont when white men came was undoubtedly far less than at present. Deer were probably most abundant in the southern part of the state, where winters were less severe, with less snow, and where lightning fires created openings in the mixed pine-hardwood forests. Shrubs and sprout growth in these openings provided food. Early hunting, however, together with logging and clearing of land for cultivation, had by 1840 greatly reduced the state's deer herd. By 1878 deer were extinct in southern Vermont and rare in the north.

A few animals were later released in the southern part of the state, and today there are some 50,000 head in Vermont. Since 1900, abandonment of farms and cut-over lands and their gradual reversion to browse have had a material effect upon the increase in deer. It should be noted also that wolves and panthers—a natural predatory check—no longer exist. Today deer in Vermont occur in such large numbers that they are taxing the carrying capacity of their winter range and causing material damage to agriculture, especially orchards. For our purpose, the important point, as Foote expresses it, is that 'changes in the land-use pattern were probably the most important factors in decline and subsequent increase in the herd.'

Limited numbers of deer, black bear, ruffed grouse, and other adapted species live in the mature forest, and these are the kinds of wildlife we can most reasonably expect the forest to produce. In some parts of the Northeast, game managers suggest the cutting of open areas in mature forest to support deer. The same practice has been recommended as a woodcock-management measure. Such intensive wildlife management is scarcely compatible with the best use of forest land. Neither can it be justified from an economic standpoint, for the cost of maintaining clearings in a forest is very likely to be far more than the return to be realized from wildlife. Yet management practices often recommended for forest wildlife are the development of such clearings, the planting of wildlife shrubs for food, the establishment of

evergreens for winter cover, and even the pruning and spraying of trees. The ends desired, in themselves reasonable, are most economically achieved when they are obtained through natural development of the forest as a plant community, and through its management for sustained yield.

The three rules of woodlot management apply in general to forest management. First of all, the forest must be protected from uncontrolled fire. Great sums of money are annually spent to exclude fire from our forests, and to suppress it once it starts. Fire towers are almost as familiar to Americans as silos. It seems redundant to state that prevention of fire is beneficial to the forest and beneficial to forest wildlife. Yet many practices given much more emphasis by the wildlife manager are far less effective than the single measure of protecting forests from promiscuous burning. Although fire is a tool sometimes employed by both foresters and wildlife managers, its use is specialized and does not negate the general rule of protection from burning.

Protection from grazing is important in forests, as it is in woodlots. It is generally less critical in forests, for the pressure usually is not so great as in farm woodlots. Locally in western forests, where domestic livestock are concentrated during the summer, grazing has a damaging effect upon both the land and wildlife. In some places exceptional numbers of big game cause grazing pressure even more damaging than that from domestic livestock, as pointed out below.

The matter of cutting is highly important to forest wildlife. As in woodlots, selective cutting is of material benefit to the wildlife of the forest. It preserves the forest type as an environment for wildlife because it creates openings and perpetuates varity in the forest cover. It encourages natural stands of food-bearing shrubs and herbaceous plants and eliminates the necessity for measures such as pruning and spraying.

In connection with the cutting of woodlots and forests, a word should be said in defense of the den tree (Plate 25). It is often referred to as a 'wolf' tree, because it is hollow and cannot be

used for logs and it takes space otherwise available to young timber trees. The preservation of den trees requires no special expenditure or additional labor over that put to the normal management of the forest. If wildlife is considered by the land operator to be a crop of the forest, it will pay to leave uncut the big trees that have hollow boles, rotting branches, or decayed trunks. The number of dens they provide is often the limiting factor in the occurrence of furbearers like the raccoon and opossum. Without den trees these mammals are absent. Many birds also depend upon such trees for nesting sites. Dependent upon holes in trees for homes are the wood duck, flying squirrel, other squirrels, screech owl, chipmunk, nuthatches, crested flycatcher, bluebird, purple martin, some kinds of mice, and the chimney swift which has been adaptable enough to use chimneys in lieu of hollow trees.

A great deal has been written about harmful forest wildlife. Rodents that feed upon tree seeds, porcupines that eat bark, and too large numbers of deer and elk have caused grief to forest managers. It can only be remarked here that these and other problems of forest management arising from the occurrence of wild animals must be considered carefully in the light of their relation to the forest environment. Frequently their occurrence results from the past use of the area, and is an effect of the measures practiced. If these measures are known and their relation to the animal is recognized, we are in a fair way to solving the problem. In some instances the damage is not what it seems. Although forest rodents do eat quantities of seeds, for example, their total effect upon tree reproduction is usually negligible in view of the untold numbers of seed produced.

It may be worth while to cite a forest-wildlife problem that involves the forest, big game, and agriculture, in order to illustrate the intricate way in which land use is woven with wildlife welfare (Scheffer and Bond 1946). In the Wenas Valley of central Washington the farmers are now demanding that something be done to control elk that come down from the mountains every winter

in search of food. An occasional elk would create no problem, even if it did cause some disturbance. But during winter when snows are deep in the mountains above the Valley, there is not enough grass and browse to feed the enormous numbers of elk that now range the hills.

Since prehistoric time, elk have been accustomed to moving from the mountains each winter onto low open areas, where there is less snow and where food is more easily obtained. The lowlands are now in farms. The elk in their annual trek, therefore, are moving each year onto farm lands. These farms have great orchards, pastures, hay fields, and crop areas which are invaded by the elk in herds. They browse the apple trees as high as they can reach, they graze the pastures, they eat up stacked hay, and even push their way through fences, snapping barbed wire before them. Farmers have been known to work in their orchards with rifles slung across their backs, and camp in tents beside their hay stacks to guard them.

It is difficult to realize that the elk that wander into the Wenas Valley now are the progeny of a half-hundred animals stocked by enterprising sportsmen in 1913. Before that time there were no elk in the forests above the Valley. By 1921 these animals had increased to 450; by 1931 there were 3000; now there are double that number. Today there are far too many for the forest to support even in summer. Forage plants are severely overgrazed, the elk taking a third of the annual forage production. The soil, with less plant cover, is trampled by thousands of heavy hoofs during spring when the ground is soft, and is eroding badly in many parts of the forest.

There are other problems the elk impose. Domestic livestock are grazed in the forest and have contributed a share to the habitat destruction. Because of damage to the range, it has been necessary to reduce the number of livestock about 75 per cent in the past 15 years. In the meantime the elk have continued to increase. Together, the combined number of elk and livestock is more than twice the estimated carrying capacity of the range.

In order to protect the forest, maintain proper range for a desirable number of both livestock and elk, and prevent damage to the farm lands of the Valley, drastic reduction in the number of elk and perhaps some further reduction in livestock are indicated.

Here is a technical problem in land management dependent upon a solution in wildlife management. It is also a problem in human relations, for the interests of forester, game manager, sportsman, and farmer must be resolved. Often the human problem is more complicated and difficult than the technical. The wildlife manager cannot afford to neglect the human aspects of his work, and the Wenas Valley elk problem is a good case in point. It is yet to be solved.

Range

Well-managed range land is a good place for wildlife. Most American range has been heavily used and much of it has been poorly managed. In many areas the original vegetation has been changed to a cover of almost worthless annual weeds, and severe erosion is a common sight. Modern range management involves the handling of livestock in such fashion and numbers that the original vegetation, or something approaching it, is restored and maintained. This results in a better cover of grass and other native range plants than most of our range areas support today. Better grass means not only better grazing for livestock but better erosion control and better environmental conditions for range wildlife (Plate 26).

Many birds and mammals find their homes on the western range—the extensive grass and shrub-covered lands that stretch from the Great Plains to the Pacific Coast. Antelope, sage hen, prairie chicken, and scaled quail are examples of range-land wildlife. The coyote, in spite of determined efforts to eradicate him, holds his own. Many small birds and mammals are also found; the abundance of some of them seems to be directly related to use of the land. Ground squirrels, kangaroo rats, and jack rabbits

apparently increase as grazing is intensified (Plate 27). That range land carefully tended and wisely used supports characteristic wildlife is shown by studies in Arizona (Monson 1941). Careful counts of birds revealed twice as many species and individuals on moderately grazed range as on comparable areas near by that were overgrazed.

In addition to the cover and food provided by a lush growth of vegetation, the third element in the triumvirate of wildlife needs—water—is unusually significant in range country. This is so because of the scarcity of water in semi-arid areas. Here again we can look to land management for aid to wildlife. One of the most important land-use practices contributing to range management is the establishment of livestock watering troughs, tanks, or wells. In order to be within easy travel distance for livestock and to aid in distributing stock so they do not intensively overgraze particular areas, stock-watering facilities are strategically scattered. There may be no more effective way to place watering devices for range wildlife than that which is used to provide adequate water for range livestock.

With respect to watering facilities, the only improvements the wildlife manager might add are refinements. One addition is the placing of a ramp or stairs in the watering trough or tank, up which animals that fall into the water when drinking may climb to safety. This simple device not only saves the lives of birds and mammals, many of which tumble into the water, but it has the added practical value of keeping the water clean for the stock to drink.

Where water is pumped or piped into small impoundments, or where it comes to the surface in springs, it is often desirable to fence the area. Fencing prevents trampling by livestock and prolongs the life of the impoundment. It also creates small havens for range wildlife. Within the fence vegetation grows luxuriantly. There pheasant, quail, sage hen, and song birds find nesting cover and refuge. Both the trough ramp and the fenced spring illustrate the close relationship between land management and wild-

life management on range land, for both practices are as useful in raising livestock as they are in the production of wildlife.

Some of the practices described earlier in this book, when applied to range land, improve such land for wildlife. Among them are streambank revegetation and protection—a practice as applicable in range land as elsewhere. The management of ponds or reservoirs for fish, waterfowl, or furbearers is also profitable in range country, where wild animals often gather in unusually heavy numbers around artificial bodies of water. Gully restoration and the protection from fire and grazing of odd areas, such as rocky breaks and occasional marshy spots along streams, also improve range land for its adapted wildlife. As in pastures, rotation grazing is a practice of value. So also is deferred grazing, which permits early ground-nesting birds to bring off their broods without disturbance.

The big game problem is nearly as well illustrated by a consideration of range land as of forests. It is difficult to separate them, in fact, because some big game species spend the summers in the forests and the winters on the range. With respect to land use, a common problem is posed by the cattlemen who claim that deer eat much of the forage that should be available for livestock. A recent study (Stoddart and Rasmussen 1945) of deer management and range livestock production in Utah throws light on this question, for it shows that mule deer for the most part graze forage plants different from those eaten by livestock. Mule deer live upon shrubs or brush, and without forage of this kind they do not thrive. Cattle and sheep, on the other hand, live largely upon grasses. The deer also inhabit somewhat different areas, for they stay largely in the mountains and foothills, where they graze heavily timbered areas and steep rocky slopes that livestock cannot utilize. Cattle graze about 75 per cent of the area grazed by deer and eat only about 25 per cent of the plants that deer eat. Sheep graze about 87 per cent of the area used by deer and eat 50 per cent of the plants that deer eat. Thus the competition between deer and livestock is not a strict one, because neither

sheep nor cattle are in constant conflict with deer, either as to the kind of range they inhabit or the kinds of plants they consume.

The authors of this Utah study provide some tentative figures to show the effect of land in good condition upon the wildlife it supports. After noting that the New Mexico Agricultural Experiment Station has shown that cattle weight at maturity, weight of weaned calf, and percentage of calf crop correlate directly with the quantity of feed, figures for mule deer are given. On good range the average hog-dressed, fall weight of mule deer bucks, does, and fawns was respectively 141, 101, and 55 pounds. On a small overstocked range the weights were 103, 71, and 38 pounds. An underfed deer is not only smaller, its capacity to reproduce is less than that of one that is well fed. Stoddart and Rasmussen summarize much of their evaluations as follows:

> In the opinion of the authors, too much emphasis has been placed upon discussion of and attempts to determine exact numbers of big game animals, whereas actually, condition of the range should be the most reliable index to proper management. . . Even if the exact number of deer were known, still in the final analysis the range must be examined to determine whether that number is too many or too few. Scientific range examination appears to be the most accurate basis for deer management. Appraisal of range land is not easy, but neither is it impossible. Surely it is the wise approach to improved game management. . .
>
> In summary, good deer and good livestock result from good land management. Every sportsman and stockman should strive for a better comprehension of what a good range consists of and how that range must be managed and protected if the deer herds and livestock herds are to continue to thrive. Even on areas where only livestock or only deer graze, still numbers must be limited and the herds managed on the basis of the range forage supply.

The more we look carefully into wildlife and land-use interrelationships on range areas, the more it seems that an understanding of range-wildlife problems will be solved through proper use of the land. Whether the question is one of controlling

rodents that presumably deprive cattle and sheep of grass, reduction of wild animals that prey on range livestock, or competition between domesticated animals and big game, the problem is brought into clearer focus when it is viewed in terms of operations conducted in the course of normal use of the land. Matters of detrimental as well as beneficial wildlife are thus seen to be in large part expressions of the kind of land management involved. Something more of this subject is considered in the following chapter.

XII ⇛ WILDLIFE PROSPECT

Demand and Supply

We are often reminded that today there are in the United States eight million licensed hunters and about as many authorized sport fishermen. To these sportsmen game animals are desirable almost without limit. For the most part, the easier it is to get a bear, deer, bag of ducks, limit of quail, pheasant, squirrel, rabbit, or trout, the better the sportsman likes it. The more licensed hunters and anglers, the greater the financial support for game and fish work, and the conservation departments like that.

The pressure from millions of sportsmen has created a demand for game species that has never been met. Perhaps it never can be met, even in America, where we pride ourselves on our freedom and opportunity to hunt and fish. We do not know yet how much wildlife our country can support under conditions of well-adjusted land use, but we are in a better position to learn how much to expect, if we admit that land in the United States will in the future be used more intensively, not less. An increasing population pressure within our own boundaries and the demands of a more closely interrelated world for food and the other products of the land will see to that.

The demand for wildlife is not confined to those who love the gun and reel, although their desires are usually heard the loudest. There is an appreciable demand for wildlife on the part of those who trap furbearers. The professional muskrat trapper of our tidal

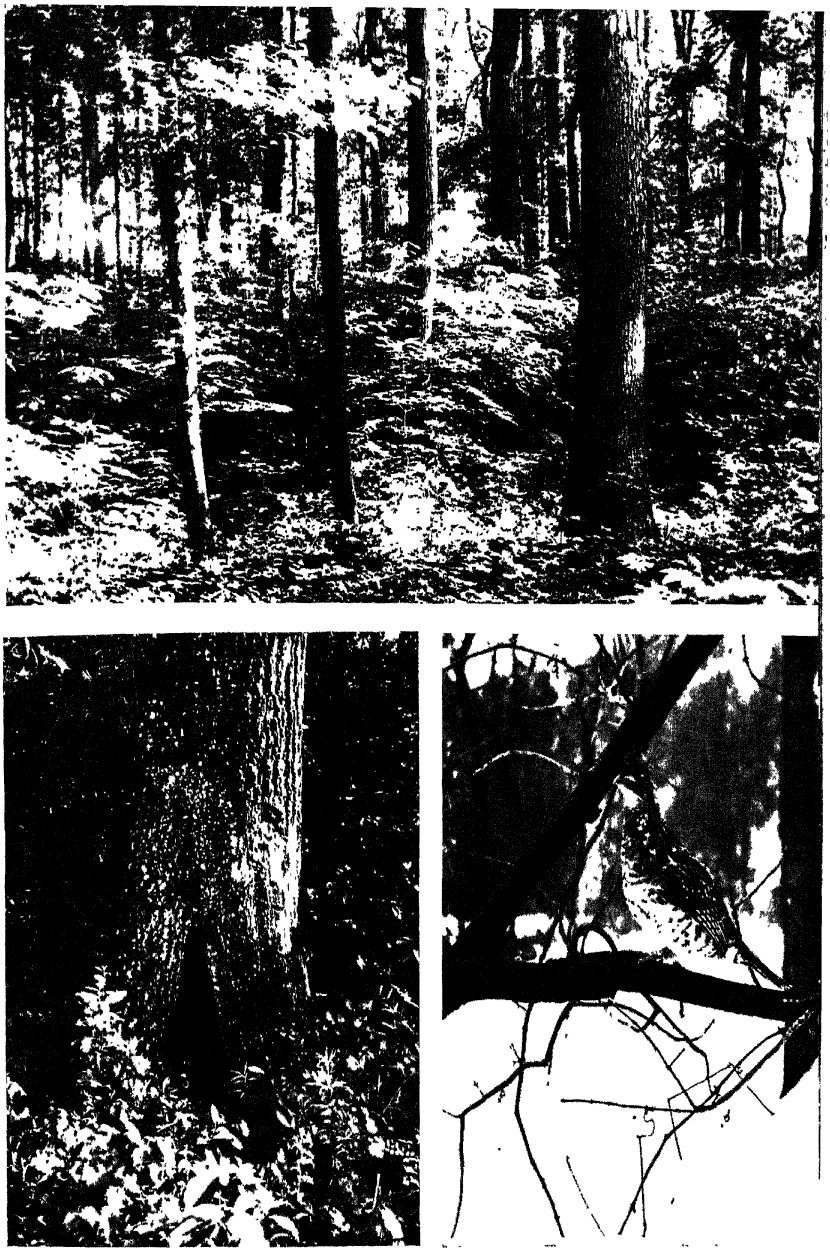
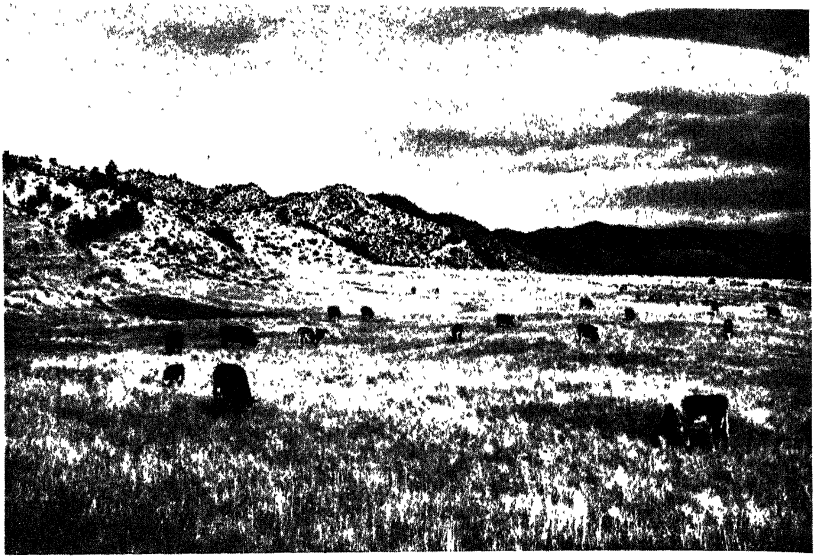


PLATE 25: TOP. The forest managed for sustained yield is a home for many kinds of wild birds and mammals.

BOTTOM. The den tree (left) provides nest and shelter for many woodland furbearers. The ruffed grouse lives only in wooded places.



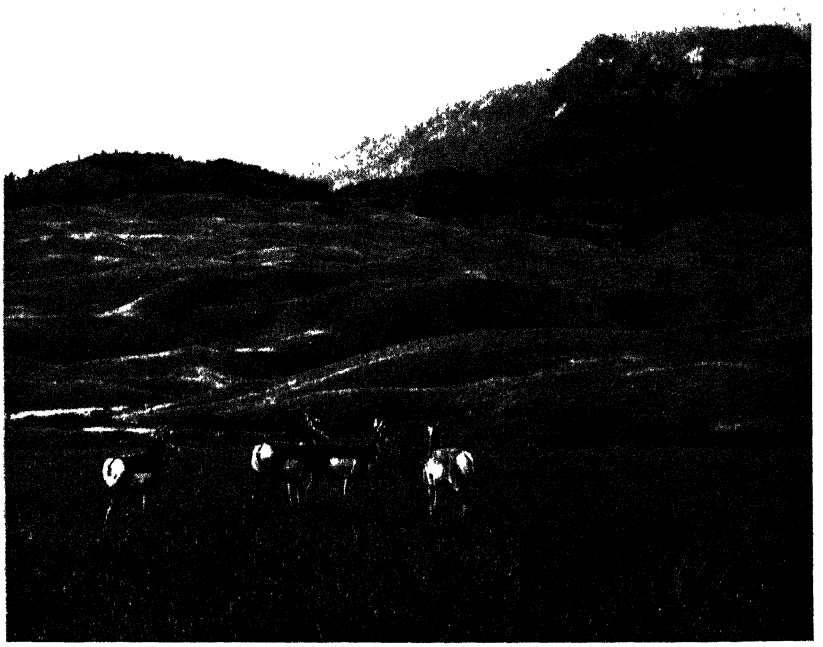


PLATE 26: TOP. The well-managed range is suitable for both livestock and range-land wildlife.

BOTTOM. The pronghorn antelope is a magnificent range-land species narrowly saved from extinction.

PLATE 27: TOP. Over-use renders range land unproductive and destroys habitat for desirable wild creatures.

BOTTOM. The prairie dog (left) and ground squirrel are rodents that may increase as range land is overused.

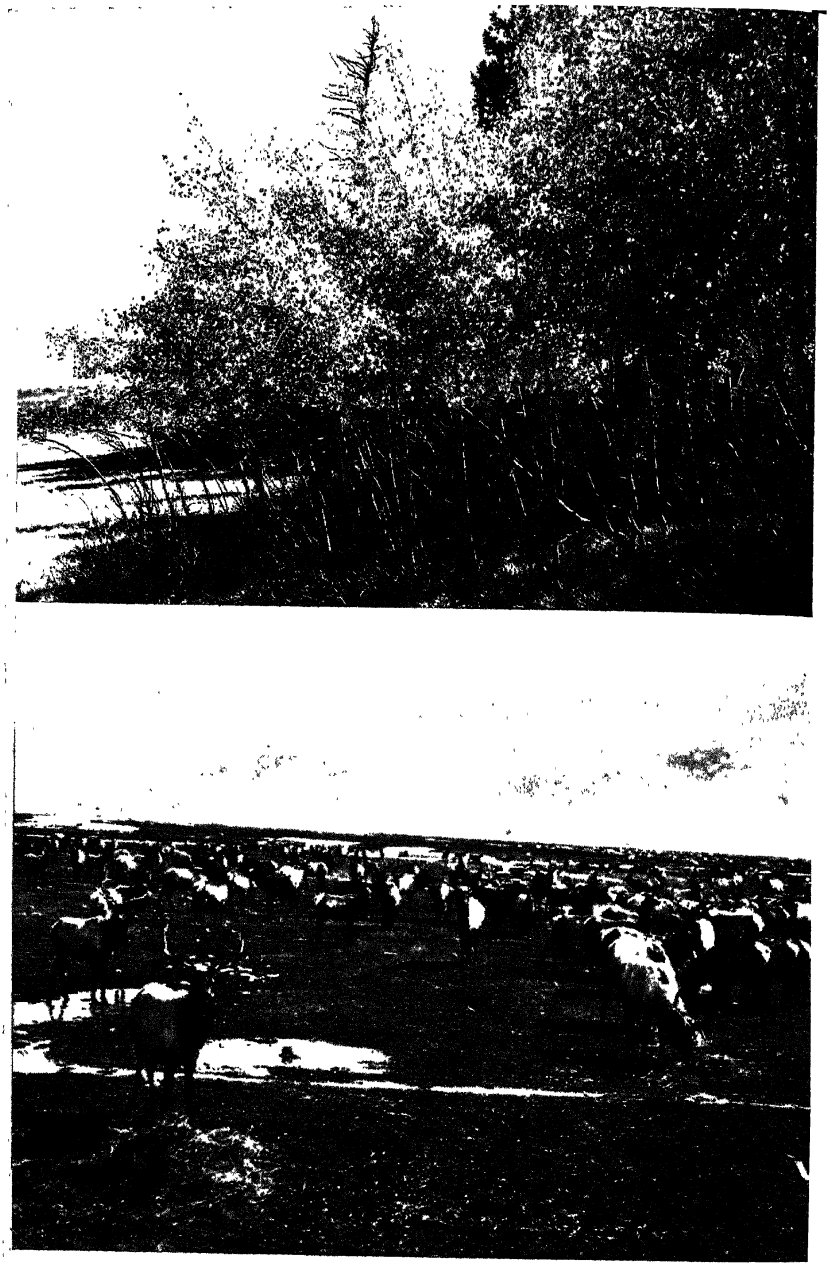


PLATE 28: TOP. The browse line indicates more deer than the habitat can support. BOTTOM. Elk are unwanted when they occur in such numbers that they must be hand-fed during the winter.

PLATE 29: TOP. The wildlife harvest is usually indicative of the way the land is used. BOTTOM. Recreational and aesthetic values are just as real as economic returns.

PLATE 30: In the West, conservation means better beef and other land products, and better wildlife habitat, too.

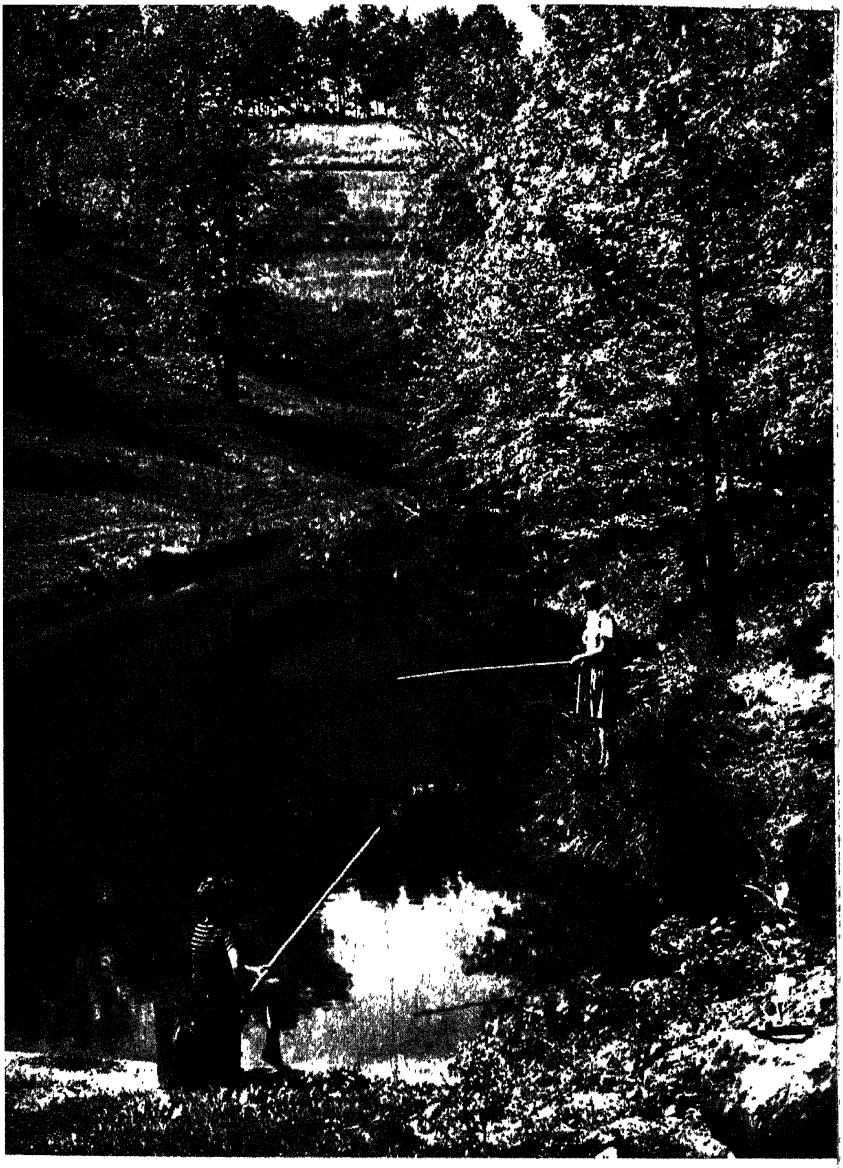


PLATE 31: Where the land is well cared for, the people prosper and wildlife finds a congenial place to live.

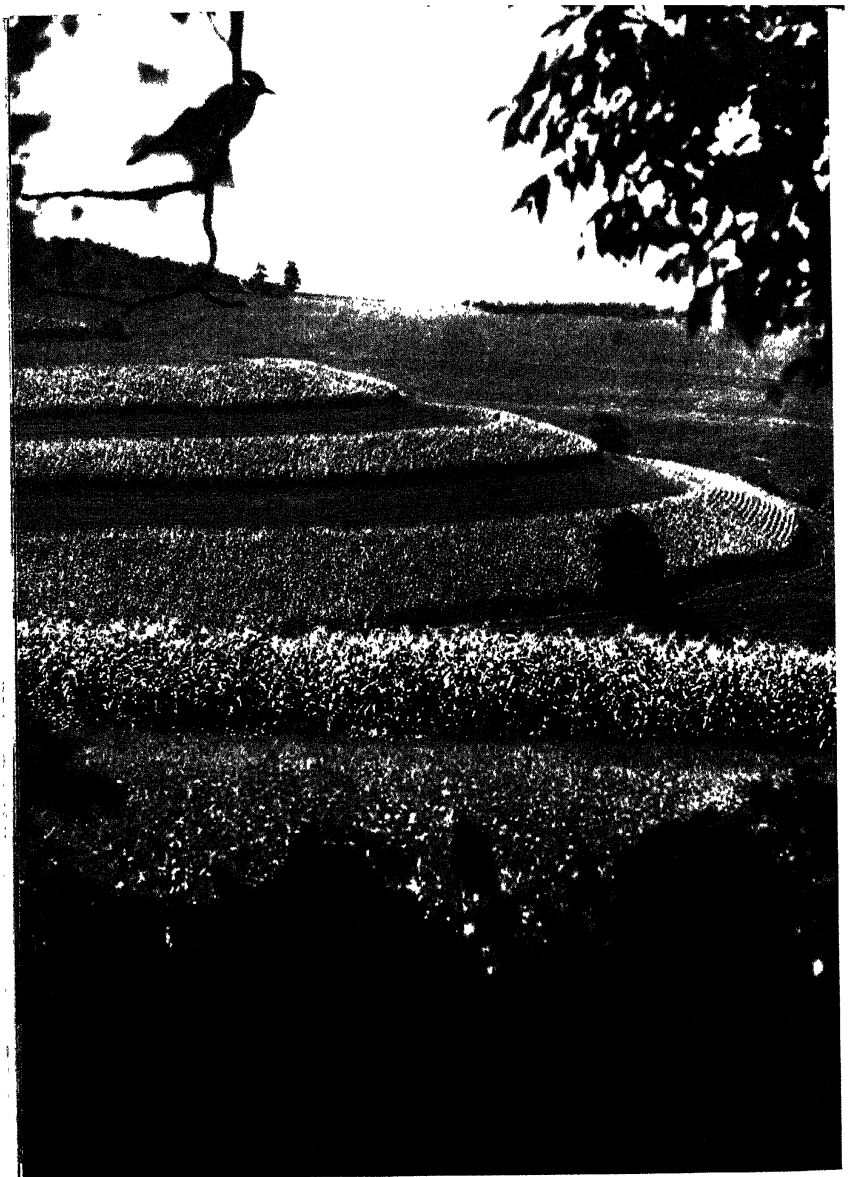


PLATE 32: In the East, good husbandry protects the soil and conserves the creatures of the wild as well.

marshlands has a vocational concern with wildlife. The heritage from our forebears lives in the farm boy who catches 'coon, 'possum, or mink. The value of native furbearers is appreciable, and it contributes to a sizable business, as already noted (p. 75).

There are a great many nature lovers who want wildlife just because they like to look at it, like to photograph it, or like to write and read and talk about it. The sight of an indigo bunting, vermilion flycatcher, or scarlet tanager is as much a delight to the bird watcher as the shooting of a bobwhite is to the hunter. There is a smaller group that likes to study wildlife—to learn its ways, its haunts, and its history. The nature lover and the student are often interested in the unusual, the rare, the unnoticed; to them the normally unnoticed is often of greatest delight. And to them the habits of even the common birds and mammals are of keen interest.

If the theme of this book is correct, we must expect to produce wildlife as a result of land use. This thesis presumes a pattern of land management in dynamic equilibrium with the physical capabilities of the land, although the pattern is not likely to be realized until land operators understand what is meant by wise land use and are trained to accomplish it. There is hope of ultimately bringing the use of land into balance with its capabilities, because it is economically the businesslike thing to do and because the life of our nation depends upon it. Much has already been done, and it is well that the wildlife manager recognize the change that is taking place. If the land is eventually used as its needs and capabilities dictate, there will not be much chance to put into refuges, or in any other way use exclusively for wildlife, the types of land more productive of tilled crops, livestock, or timber.

It has been estimated by the Soil Conservation Service that there may be almost 600 million acres of land in the United States that can ultimately be devoted to cultivated crops, although 100 million acres of this land can be cultivated only occasionally or must otherwise be used very carefully. We have already seen that 100 million acres is used best when devoted to wildlife. This

leaves more than a billion acres—of our two billion total—for grazing, wood production, or other purposes. Every kind of land can produce wildlife, much of it in abundance. The wildlife adapted to each type of land use, however, occurs more as a natural component of such use than it does as the result of extra effort especially directed toward its production. This is not to say that the wildlife manager could not, by intensive quail management on cropland, produce more quail than such land will support when used for crops. But it is to say that quail can be produced reliably and economically on cropland that is well managed under a system of careful husbandry or conservation farming.

Under conditions of intensive use, the land must be carefully evaluated so that each acre is dedicated permanently to its most productive purpose—within the limits of its ecological characteristics, the economy of the community, and the social environment. When land is used in accordance with its natural capacity for production—and on millions of acres in the United States its use has already been so aligned by soil-conservation work in the last ten years—the pattern of the land takes new shape. And to this pattern wildlife readily adapts itself.

Today in the United States there are about 347 million acres devoted to cultivated crops, 44 million acres of which should not be cultivated, but should be converted to some other use. If, as our population increases, we use several million acres more for crops, we shall then have more of the kinds of wildlife that are naturally adapted to cultivated lands. This will mean less of the kinds of wildlife naturally adapted to pasture and woodland. Wherever land-use conversions bring use of the land into better balance with land capabilities, there will be accompanying changes in habitat and kinds of wildlife. This is a broad approach, and it may permit many exceptions, but it acknowledges a development in our history no thinking person can deny. Ecological adjustments in agricultural land use apply to the development of a plan for the operation of an individual farm or ranch as well as to major conversions. In fact, individual units form in aggregate

the larger picture. They provide us also with a trustworthy approach to practical wildlife management.

No one has ever calculated the potential wildlife production of the United States. Such a calculation would be pointless unless we knew something of what was likely to be done with the land. In the past, use of the land has changed so rapidly that an estimate of the kinds of wildlife, let alone its quantity, was not possible. Today there is little to be gained by correlating potential wildlife occurrence with the land, for we are in the process of readjusting our use of the land on a major scale. We have learned, however, from careful classification of the lands of the country according to their capability for different kinds of use, the approximate amount of land that can ultimately be devoted to production of cultivated crops, livestock, forest products, and wildlife. We know these figures by estimated national totals. Already in many soil-conservation districts throughout the country, we know it in detail, farm by farm.

We know something also of the kinds and quantity of wildlife each of the recognized types of land use will support. Consequently, it is possible to estimate the supply of wildlife for each local area where the land-use classification is at hand. As the land-use conversions take place and the new pattern of fields, pastures, and woods takes permanent shape, we have a basis for determining the supply of wildlife. As this information accumulates, there will be something to which the wildlife manager can apply his energies with the conviction that they are well spent.

The sobering effect of such an approach is that it causes us to pause and ask many questions about what is being done in the interests of wildlife. Reference has already been made to wildlife practices that can be challenged from the standpoint of their land-use value. It also poses the question whether there is not a limit to the number of hunters and fishermen who can expect to obtain a grouse, pheasant, or bass, and whether the carrying capacity of the land does not apply to those who hunt as well as to that which is hunted. And although we do not know yet how

much wildlife we can depend upon in America, it is certain that when the supply is determined it will be evaluated most reasonably by direct reference to amounts of land devoted to adapted uses, for which acreage figures are fast becoming available.

Unwanted Wildlife

There are many persons who want wildlife, and there are many kinds of wildlife that are wanted. On the other hand, there is much wildlife that is not wanted. We have even inherited an attitude toward certain forms of wildlife that makes it difficult to judge it fairly. Much of this stems from the American settler's acquaintance with wildlife and the conviction he absorbed, along with other ideas and traits, about 'harmful' animals. As Cameron (1929) put it:

> Because of hasty generalizations, or conclusions jumped-at on very meagre evidence, or old fables, traditions, and proverbs of the Mother Goose sort to which he had fallen heir, he condemned out of hand as measures to husbandry several birds and animals which were as a matter of fact menaces to agricultural menaces rather than such menaces themselves. And having condemned them, he proceeded to kill them on sight, as did his children after him.

Some kinds of wildlife are both wanted and unwanted. To the hunter, ring-necked pheasants are wanted; to the farmer they may be a pest that is eating his corn. The bad blood that exists between sportsmen and farmers relates in part to this difference in attitude toward the wildlife one of them finds desirable, the other undesirable. It is intensified by outmoded concepts of wildlife as property, to lack of understanding of each other's interests, failure to recognize private property, thoughtlessness, and intolerance.

The differences between sportsman and farmer are not easily reconciled, but it is of incidental interest at this point that the land-use approach to wildlife management suggests a possible

solution even to this dilemma. Sportsmen, growing conscious of the value of good land management to wildlife, are offering to assist farmers in the establishment of approved land-use practices. In the Southeast, for example, state game and fish departments are providing farmers with seed of sericea and bicolor lespedeza for the planting of eroding field borders. The sportsman is learning what is being done on the land, and his money is helping to accomplish it. It is not impossible that the farmer and sportsman will cultivate a mutual interest in the product of the land if they treat it together. When the farmer benefits by better land use and the hunter by game to shoot as a result of their joint efforts, the way is pointed toward better understanding and possible resolution of at least some aspects of the farmer-sportsman conflict.

There is some wildlife that is of little interest to the dilettante, student, or hunter, but which is of vital concern to the land operator. Much of it is the unwanted wildlife of real significance (Plate 28). Its occurrence is frequently related directly to land use, and there is increasing evidence that its abundance is closely correlated with the degree to which we have misused the land. We may have wild animal pests no matter how well we care for the land, but a few examples of how poor use aggravates the trouble may show also that there is less difficulty with wild animals when the land is used well.

Sometimes wildlife is unwanted because it is a nuisance. Muskrats, raccoons, pheasants, and squirrels will eat corn. Robins and waxwings will eat cherries and other fruits, sometimes stripping the trees. Weasels, foxes, and hawks sometimes kill poultry, and skunks will eat eggs. Groundhogs make treacherous holes in fields, and destroy pasture or hay plants. Experience with the depredations of these animals often creates an everlasting enmity on the part of the farmer. The list of wild animals that cause us trouble is a long one. Often we are willing to put up with occasional or limited interference, because the animals have a value surmounting the damage they cause. This is true of game birds and fur-

bearers particularly. The depredations of the skunk are considered tolerantly when we learn that his diet is 80 per cent insects and that, on the whole, he is a helpful creature.

Much of the occasional damage from wild birds and mammals is due to the fact that we have stripped the land so clean that the animals are forced to come practically into our homes for food. It is generally true that where farms, woodlands, and the range are managed best, there is least harm from wild creatures. On farms where there are such landscape features as field borders, hedges, ponds, windbreaks, and protected odd areas, both birds and mammals are likely to find cover and food without foraging into orchards, crop fields, and barnyards. The waxwings will eat fewer cherries if there are hedges of fruit-bearing plants for them to utilize. Hawks will not kill so many chickens if field borders harbor more of their natural prey. The skunk will eat fewer eggs if there are odd areas in which he can find his usual fare. In short, if the environment provides wild creatures with suitable homes, they are likely to find it less desirable to forage in the places men habitually frequent.

The case of the white-tailed deer has already been reviewed. Its abundance is owing in large part to clear cutting of extensive forests and the subsequent development of large areas of browse. Had the logging been selective, with only mature trees felled and care taken in the handling of the remaining forests, the deer probably could never have become so numerous, for such a habitat would not have supported them. The pest that deer become, therefore, is traceable to the way we use the land.

Burrowing mammals are often purported to be a great nuisance in earth fills, dams, terraces, and other small structures. There are indeed numerous instances of such damage by mammals, although much destruction charged to animal life in fact has other causes. There is good reason to believe that earth structures are far less susceptible to damage if they are constructed with some knowledge of the habits of the animals likely to injure them. This was nicely shown by a study (Compton and Hedges 1943)

of contour furrows, contour dikes, and stock pond dams in the Southwest.

Two species of kangaroo rat, the banner-tailed (*Dipodomys spectabilis baileyi*) and Ord (*D. ordii montanus*), were studied to learn how their ramifying burrows penetrated the structures in which the mammals found acceptable nesting conditions. The burrows endanger contour dikes by creating channels through which water flows, but they may actually improve the efficiency of contour furrows by increasing water infiltration. In stock ponds it was found that rats cannot perforate a fill more than 13 feet thick, so that a well-designed dam thicker than 13 feet is sufficient protection against the mammals. It is possible, therefore, to provide protection against, and in some instances to reduce, unwanted wildlife by special attention to the design of conservation structures.

It is almost axiomatic that wherever man's use of the land is most precarious—where there is an unusually delicate balance between land use and environmental conditions—there we are likely to find the most acute difficulty with wild animals. In the semi-arid areas, where use of the land depends upon careful utilization of whatever water is available or can be gathered and saved, there is severe damage from native mammals. Throughout the range country the activities of such animals as kangaroo rats, ground squirrels, prairie dogs, and coyotes tend to influence the activities of man so much that millions of dollars are spent every year trying vainly to get rid of them. What we are learning of the habits of the burrowing rodents of the West indicates that the very use of the land itself is responsible for the large increases of most of these mammals.

To understand the relation between rodents and land use we must understand something of plant ecology. If, for one reason or another, the soil of a vegetated area is laid bare, the plants that repopulate that area are usually not those that grew there before the area was disturbed. Instead, the first plants to appear are annual weeds. These are followed by perennial weeds and

grasses, and these, finally, by perennial grasses like those occurring in the area before disturbance took place. Now it so happens that range vegetation, when it is grazed, tends to go backwards through this succession. With slight grazing a native grassland, composed of perennial grasses and associated herbs, will gradually change into a mixture of grasses and weedy perennials. With more intensive use these plants give way to perennial weeds, the perennial grasses disappearing entirely. If the range continues to be intensively grazed, and much of our range land has been so used, only a sparse cover of annual weedy plants remains.

The clue to the relation between the increase of unwanted range-land wildlife and the use of the land lies in the knowledge that there are certain species of birds and mammals naturally associated with each of the types of vegetation through which the range changes as it is subjected to use. Many of the small rodents that are so abundant today on range land throughout the West seem to thrive best on weeds, not on grasses. They seem also to like open country. There is reason to believe that they originally occurred less abundantly when the range was composed of perennial grasses with scattered succulent herbs. As the range changed, and weedy plants became more abundant, the rodents became more numerous. This relation was summarized by students of Arizona range ecology (Vorhies and Taylor 1940) in the following words:

> As the grazing range deteriorates, in various parts of the Southwest, brush and small trees . . . cholla cactus and prickly pear tend to increase. The superior perennial grasses tend to be replaced by annuals . . . and numerous weeds become abundant . . . cottontails, cotton rats, meadow mice, harvest mice and other species characteristic of thick grass tend to decrease, and jack rabbits, kangaroo rats, prairie dogs, ground squirrels, and wood rats . . . tend to increase.

Not only does it appear to be true that misuse of land is the primary cause of the increase in range rodents that compete with livestock for forage; it is conversely true that better land use will

decrease their numbers. If grazing cattle are decreased to a number that will permit the range to remain in a good stand of perennial grasses—and this protects the land from erosion and yields better beef—the rodents do not thrive in great numbers. Good range has few rodents, poor range has many.

In a recent review of this subject, Richard M. Bond (1945) has pointed out that rodents do not feed with the lack of choice of a mowing machine. They exert a *dynamic* force on the vegetation. By feeding on weeds, rodents may actually speed the growth of other vegetation. For if livestock numbers are reduced, the activities of rodents that eat weeds may result in less competition between the weeds and the grasses that normally tend to come in when grazing pressure is less heavy. Bond concludes that we need much more information on this subject, but it seems highly probable that 'some rodents, under some conditions, may assist in the recovery of deteriorated ranges by differential pressure on plant species typical of early successional stages.'

The relation between land use and rodent numbers is so intimate that it would seem imperative to study it very carefully before we spend much money on poison campaigns to exterminate prairie dogs, ground squirrels, and their kin. The discovery of a substance especially toxic to rodents, revealed in Experiment No. 1080, is heralded in national magazines as a triumph. We may indeed have found a good rat poison, but its use as the solution to range-management problems is in a category with dependence upon a new type of destructive bomb as the solution to differences between nations. The reasonable solution to a problem arising from use of the land—as in the case of range rodents—is to look more carefully to land use.

There is a demand on the part of a great many people for the production of some kinds of wild animals, and there is, on the other hand, a demand for reduction or control of wildlife. The wildlife manager has a responsibility for both, and it is his task to increase desirable species and to decrease undesirable forms,

or at least the damage from them. For our purpose, it is important to note that, just as wildlife can be benefited by useful land-management practices, so can damage from wildlife be reduced by attention to the land. The latter is a highly significant point all too infrequently recognized. We need to learn a great deal more about environmental influences upon animals than we know now to understand fully the effects of land use upon birds and mammals that cause us trouble. It is the task of the wildlife manager to learn what he can about this matter, and to look to modifications of land use as a very important factor in the control of damage by wild creatures.

XIII ⇛ THE COST AND THE HARVEST

We have begun to look upon wildlife as a crop of the land, just as corn, cotton, beef, and timber are land products. This is a reasonable attitude, and it conditions our thinking. If wildlife is considered a crop, it follows that major attention must be given to the treatment of the land that produces it. We can no more expect to grow corn without selecting a good soil, cultivating and fertilizing the field, and harvesting the crop, than we can expect to raise quail without attention to odd areas, field borders, and other components of a proper habitat. Barren soil will not yield a crop of corn—neither will it yield a good crop of wildlife.

Inherent in the concept of wildlife as a crop is the question of how much it may cost to produce wildlife, a matter all too infrequently considered. And along with costs, consideration of a crop demands that attention be given to harvesting. The worth of wildlife must be measured, as we have already recognized, in many terms other than sheer economics—its influence upon culture, its aesthetic value. In this chapter, however, we shall look briefly at the matter of economic returns.

Wildlife Worth

There are estimates of the dollars-and-cents value of wildlife. It has been stated (McAtee 1937) that for the humid eastern

portions of the United States the value of wildlife annually averages 14 cents per acre for meat and 23 cents for destruction of insects and other agricultural pests. In Ohio the bobwhite quail is protected the year through because of its insect-eating value, estimated to be $25 annually. For arid regions figures are given as 4 cents and 13 cents per acre per year for meat and pest-control values respectively. Farm ponds intensively managed for fish yield a crop worth several dollars per acre per year. The value of various lands is higher if they are specifically treated for wildlife production.

At the conservative figure of $25 per man, United States sportsmen in some years have spent an estimated $200,000,000 for license fees, transportation, board, equipment, and other expenses incident to hunting and fishing. A large portion of the tourist business—perhaps one tenth—can be credited normally to trips by hunters and fishermen. The result is an expenditure of hundreds of millions of dollars every year by American Nimrods and Izaak Waltons. To the land operator, however, these values are of no great significance, because he realizes little direct return.

We should not expect private land operators or public agencies to continue to produce any crop unless it is profitable. Thus we must look carefully to the cost and the consequences of producing wildlife. Upon some kinds of land best suited to wildlife use, such as marshes, it is profitable to invest a great deal of money, for yields of muskrat pelts can run very high. On other kinds of wildlife land, such as odd areas, little investment is justified, although protection from fire and grazing, which costs little, may pay off in the form of a covey of quail or a few furbearers. As with other lands, the profit from wildlife lands can be correctly estimated only in view of the investment.

One reason some of the old-line wildlife-management measures have fallen into disrepute is their economic weakness. This is particularly true of the practice of raising in captivity game animals that are released in the wild. There are sound ecological reasons

for condemning this practice because animals are frequently released in an environment incapable of supporting them. And there are economic reasons, too. In a critical analysis of game and wildfur production and utilization on agricultural land in the United States (Miller and Powell 1942) it is pointed out that:

> The game farms devoted to game birds have not yet produced birds at a cost low enough to warrant their use for public shooting. The present cost of these birds, raised to maturity, is estimated to be between $1.50 and $2 each. As hunting licenses sell for $1 to $3 and permit the holder to kill six or more birds annually, it is evident that the State cannot depend upon pen-reared stock to meet the demand for shooting.

Even though it may be possible to raise some species at a cost less than the figures cited, it remains an expensive practice. Many other things undertaken for the express purpose of increasing wildlife, without consideration of all influences bearing upon its production, probably would be found to be equally unsound economically, were it as simple to get at the costs and benefits involved.

In contrast to the cost of producing wildlife in captivity, it may be worth while to look at wildlife land itself in terms of profit, although figures are scarce. Often the return from such land, per dollar invested, is higher than the return from land in other uses. Muskrats from marshlands provide one of the most productive of wildlife crops, from Canada to the Gulf Coast. In Ontario east of Detroit, wet farmland that had been unprofitably drained was flooded in 1929. By 1942 there were more than 8000 muskrats taken from 1600 acres, grossing a yearly return of about $14 per acre. In Manitoba, along the Saskatchewan River, control of water levels in a few years yielded an income of $2.56 per acre from muskrat pelts over an area of 140,000 acres. In northern Illinois, muskrats sold for a price that averaged $3.32 per acre of marsh; in Texas the net return was $3 per acre from land it cost nothing to manage; and in the coastal marshes of Louisiana,

where great acreages are devoted largely to muskrats, the profit is about the same as that in Texas.

The figures in the preceding paragraph are given by Frank C. Bellrose, Jr. (1945) in a review of the values of marshlands. In his own studies of the Illinois River bottomlands he points out that, from a thousand-acre shallow expanse of water and marsh called Rice Lake, the owners over a six-year period received an average annual income of nearly $900 from sale of fur pelts, more than $2000 from leasing duck hunting rights, and almost $400 from boat rentals to hook-and-line fishermen—this without the adoption of special land-management measures for wildlife production. Such figures show that muskrat land may also yield income from other wildlife as well.

Another type of wildlife 'land' for which some economic notes are available is the small pond. A recent evaluation of a five-acre artificial impoundment in Connecticut (Moss 1942) shows that the muskrats taken from the pond environs from 1932 to 1940 averaged a return of $6 per acre, even though the pond was close to a small village. Figuring an additional income from mallard ducks, frogs, and fish, it was conservatively estimated that this pond area provided an annual return of $10 per acre for the wildlife produced.

The examples above deal largely with returns from marshlands, the kind of wildlife land that occurs in such large expanses along the Atlantic and Gulf Coasts that it often seems to be economically the most important kind. As noted in an earlier chapter, however, there are sizable acreages of field borders, odd areas, and other kinds of wildlife land. Although data on their economic value are few, they yield some return. To serve as a rough indicator of the values of various types of wildlife land, a summary was made of reported returns from muskrat, opossum, skunk, raccoon, and mink taken in various habitats from various parts of the United States. The annual value of the furs trapped per acre in relation to types of land was as follows (Anderson 1945):

Type of Land	*Fur Value per Acre*
Drainage ditch	$21.00
Pond (water area)	11.00
Streambank	8.50
Marsh, managed	7.00
Strip-mined area	5.00
Lake shore	3.25
Marsh, unmanaged	2.75

It is not from the wildlife lands alone that we look for returns from wildlife. It is one of the advantages to be derived from good land use that wildlife can usually be produced on land that is primarily managed for production of some other crop. That a good crop of wildlife can be gleaned from land devoted to other uses is illustrated by the record from an eighty-acre farm in Mississippi. Lee E. Yeager (1937), a wildlife manager, kept records on this farm for a ten-year period, 1926-36. Thirty of the eighty acres were in cultivation—corn, cotton, peas, and associated crops—and fifty acres were in lightly grazed oak, gum, beech, and hickory woods with a stream running through them. The furbearers trapped, in order of abundance, were opossum, mink, raccoon, red fox, and weasel. The average annual net income, minus cost of traps and ammunition for killing bait, was a little less than $1.15 per acre.

Although we do not know how much was invested in this Mississippi land, we do know the return per hour for the time and investment associated with the wildlife harvest. Considering the work involved in preparing bait, setting traps, running trapline, skinning, curing and packing skins for shipment, and taking up and storing traps at the end of the season, the return averaged 75 cents per hour. This was done without special attention to the farm for its wildlife. At that time the return compared favorably with wage rates in the industrial field, and was several times that of the hourly rate received by farmers for their normal work in the locality.

Cost is an item of importance not only in the production of desired wildlife, but also in the control of unwanted species. As

pointed out in the preceding chapter, rodent control on range lands is often ecologically inadvisable. It is usually unsound economically also. A qualified mammalogist, Charles T. Vorhies, looked carefully into the rodent- and rabbit-control work conducted by the government about ten years ago on an experimental range area near Tucson, Arizona. The control involved destruction of cottontails, jack rabbits, kangaroo rats, and ground squirrels. Inasmuch as the example is more or less typical of operations still being recommended, Vorhies' (1936) conclusions are worth quoting:

Nearly $8 per head of livestock on the range was spent on control work. The cost was 19 cents per acre, which may seem cheap enough until we learn that the cattlemen are paying scarcely 4 cents per acre per year for it. Comparing the cost on the basis of livestock values, we get an interesting result. The estimated cost of killing 12,280 jack rabbits was $3,885.92, or about 32 cents per jack rabbit. According to Taylor and Vorhies it takes 74 antelope jack rabbits or 128 California jacks to consume as much valuable forage as one cow. Therefore to remove the antelope jack-rabbit-equivalent of one cow cost $23.68; and to remove the California jack-equivalent of one cow cost $47.36; the livestock was worth possibly $20 to $25 per head. Was it good economy, aside from any other question? Would any cattleman spend that much on his range to get rid of rodents?

The author of this analysis is fully aware, also, of the land-use and other ecological aspects of the problem. He refers to jack rabbits, for example, as 'animal weeds' comparable to plants that are an effect, rather than a cause, of the poor condition of the range.

The Harvest

The point is often argued: Can the land operator afford to manage wildlife? The economic advantages are high only under certain conditions, as from muskrat marshes. The recreational values are often derived by sportsmen who do not own land. The aesthetic and cultural values are intangible assets. There is likely

to be an economic advantage to the landowner only if his investment is low. Manifestly, the farmer cannot afford to replant food patches of grain for wildlife every year, and devote cropland to it in the bargain. Neither is his investment low if he has to fuss with gadgets like flushing bars or take time to pamper wildlife with hand feeding in the wintertime.

Contrary to what many people believe, however, most farmers want wildlife, if for no other reason than to have it around. They have no objection to doing things that encourage it. It is at this point that the land-use practice secondarily of value to wildlife becomes a measure economically reasonable. It is then that the careful treatment of the streambank, gully, field border, windbreak, hedge, and odd area become of paramount importance in the production of wildlife, economically as well as environmentally.

The harvest of the wildlife crop is usually more difficult to evaluate than the harvest of other crops (Plate 29). Not much study has been given this phase of our subject, although most game laws are predicated upon what is considered to be a safe number to take. The idea seems simple—you just leave enough for 'seed,' to make sure that there will be game next year. It is not always easy, however, to learn the productivity of a species in a given locality. Formulae have been devised to measure productiveness, as by considering the concentration of animals to be the result of the population weighed against the sum of the environmental factors. Usually the number of animals is not well known and it is not easy to determine the influence of habitat factors, especially the factor which may outweigh all others. Consequently, the formula employed may be worth very little.

Theoretically, the harvest is often calculated as follows. Suppose that a covey of 10 quail inhabiting a given area divides into 5 pairs during the breeding season, and that each pair produces 14 eggs from which 5 birds grow to maturity. This is biologically reasonable, and it would result in 25 additional birds—5 from each of 5 pairs. If 15 were killed by hunters as the harvestable surplus, and 10 died later because of severe weather, disease, old

age, predators, and action of other factors, there would be 10 birds left to start the next breeding season, and the covey could presumably be maintained indefinitely.

Suffice it to say that many schemes comparable to this have been worked out to guide the harvest of other game species, with detailed methods for attempting to census populations and weigh environmental influences. For our purpose it is enough to recognize that the harvesting of the wildlife crop must be done according to arbitrary rules, and that the crop itself depends to a great extent upon a complex environment modified by the condition of the land.

In the fisheries field, new ideas about wildlife and its harvest are taking shape. It must be admitted that there are some fundamental differences between fish and game management. Fish reproduce by laying millions of eggs; birds and mammals do not. Productivity among fish is usually measured in terms of pounds, not individuals, because individual fish of a given species may vary tremendously in size according to the availability of food. Notwithstanding such differences, concepts now crystallizing in aquatic biology may ultimately affect the guides and rules we apply to terrestrial animals.

The management of the small farm pond for fish points a lesson in harvesting the crop. We find some of the leaders (Swingle and Smith 1942) in this field stating:

Experiments have indicated that only approximately 50 per cent of the legal-sized fish can be removed from a pond each year by fishing. When the number of fish in the pond is reduced, the food for those remaining increases, and as the food per individual increases, the fish bite less often. During this period of poorer fishing, the fish grow rapidly; as the maximum weight which the pond can support is approached, the fish bite more and more readily, and fishing once again becomes good. Alternating periods of good and poor fishing are therefore to be expected in all ponds which are adequately fished. One of the primary purposes of pond management is to reduce to a minimum the frequency and length of these periods of poor fishing.

In small ponds, therefore, it is literally impossible to take too much of the crop. It is even unnecessary to save 'seed' so long as the pond is in good condition—that is, so long as the environment remains favorable.

Nor is this concept confined to small ponds, which are often claimed to be a closed world within themselves and thus different from other environments. In Norris Reservoir, a very large artificial impoundment on the Tennessee River, fishing became poor, especially after the season had been open a few weeks. In order to improve the fishing, tradition dictated a shorter season, reduced creel limit, and increased size limit. In short, the conventional conclusion would have been that the lake was overfished and that angling must be restricted. An investigation (Eschmeyer 1944) proved, however, that the lake was well stocked, that only a small portion of the fish was being caught, and that fishing during spawning season did no harm. A number of other facts led to discarding the closed season, and even to the authorities' informing fishermen of where the fish were located.

The idea that a favorable fish habitat cannot be overfished has extended even to the management of the Great Lakes. As a result of years of careful work at the Franz Theodore Stone Laboratory on an island in the west end of Lake Erie, Thomas H. Langlois, the Director, emphasizes that the welfare of fish, whether in stream, pond, lake, or fraction of the sea, is a direct function of their environment, and depends upon this far more than upon laws and their enforcement, artificial propagation, and administration. Langlois (1944) points out that existing laws generally place ownership of all wild fishes in the state, grant privilege of acquiring them to persons who have bought licenses, specify the time of year, month, day, and other conditions under which licensee may fish, and the kinds, sizes and amounts of fish he may take.

Things that may seem to have little or nothing directly to do with fishing may in fact have a great deal to do with fish welfare, because they affect the environment in which fish live. Some of

these are control of pollution of public waters, construction of farm ponds and other small water impoundments that serve as fish farms and stabilize stream flow, management of drainage ditches and streambanks, and planting of trees and establishment of other vegetal cover that will keep erosion silt out of streams. Along with research and the removal of restrictions on fishermen, Langlois recommends for Ohio that:

The provision of clear water, of regulated volume, free of toxic materials involves prevention of pollution, prevention of silt turbidity, and stabilization of stream flow. Stream flow can be stabilized by headwater reservoirs which should be built. Silt turbidity can be prevented only by keeping erosion in constant check on the land and along the streams. Techniques are known for doing this and should be used. Pollution can be prevented by enforcement of laws, and should be done.

Thus the harvesting of fish is beginning to rest on a new set of values, and the relation between fish life and the use of the land is being viewed in a fresh light. If such a relationship holds with respect to aquatic life, it must hold just as closely with the birds and mammals that live upon the land itself.

We are now brought to consideration of a very important point. We have seen that there are specific things a land operator does in the name of sound land management that are also good for wildlife. When land is used in such fashion that it increases yields of crops and preserves the soil, there is immediate as well as long-term profit. Experience of the past decade has shown that soil can be held in place by correct husbandry and that production of common farm crops—corn, cotton, tobacco—is increased as much as one third by such methods. Pastures managed for erosion control provide increased yields of milk and livestock. Woodlots profit by soil-conservation treatment. Proper land-use programs include the adoption of some or all of the practices discussed in this book. They help the farmer or rancher save his soil and increase crop yields. They increase yields of wildlife, which is also a crop of the land.

The point at issue is: What does the land operator gain by the increased wildlife he has produced? He may obtain three possible results. The first is a biologic or ecologic benefit. The second is an intensified demand by hunters and fishermen for the fish and wildlife produced. The third is an economic return from the wildlife comparable to that realized from the production of other crops.

We have already mentioned the biologic or ecologic values of wildlife as they relate to use of the land. The importance of looking carefully to the relation between living things and land operations was recently treated at length by the author in *Natural Principles of Land Use* (1944). The ecologic value may well be the most significant of all benefits from wildlife. Where use of the land is in equilibrium with environmental factors, wild animals seem to occupy an inconspicuous place. On well-managed land there are few of those harmful species—for example, kangaroo rats and ground squirrels—that so often thrive on misused land. Predatory animals, such as hawks and foxes, that sometimes prey upon poultry cause less damage where conditions provide their normal food. Insectivorous birds and mammals that contribute their share toward control of pests are more abundant where the land is well cared for. Although it may not always be so, it is on the whole true that land wisely husbanded supports useful wildlife, while land badly handled permits the occurrence or spread of species that tend to be harmful or injurious.

The presence of wildlife results in demands by sportsmen. Having paid for a license that permits them to fish or shoot, they must find a place to exercise that privilege. They cannot legally trespass upon land owned by others. On the other hand, game does not belong to the landowner but to the state. And the sportsmen are licensed to take game, within limitations. This dilemma is further complicated by the fact that the demand for wildlife will become greater on land well managed, because it produces more wildlife than land poorly treated.

The presence of sportsmen, even when permitted by the land-

owner, often results in damage. Many sportsmen do not understand farming. They leave gates open, or fasten them improperly. They trample crops, break down or spring fence wire. They may injure or kill horses, cattle, or sheep by thoughtless gunfire, and they occasionally cause fires in fields, woods, and buildings. They become, in short, a nuisance and a threat.

This brings us to the crux of the matter. If wildlife is a by-product of good land use, and some of that wildlife is game or fish, what can it profit the farmer or rancher on whose land it occurs? If hunters and fishermen are disliked, they can be kept out by the enforcement of trespass laws. But this results in a stalemate between sportsmen authorized to hunt game legally belonging to the state and landowners who legally prohibit trespass. Resort to public hunting areas will not solve the difficulty. Americans look upon hunting as their traditional right. It would be impractical to purchase land in sufficient quantity to meet the demand.

If there is a broad, practical answer, it probably rests in the consideration of wildlife as a crop of the land, even though there is no other crop with the same legal status. As a crop, wildlife should have a market value, determined by demand, quality, availability to market, and other factors. Like other crops, wildlife should be harvested in season and enough of the 'seed' must be saved to assure a crop next year. Such determination is made in the case of wildlife by the state or, in some instances, as with migratory waterfowl, by the Federal Government. The crop of wildlife is usually harvested by those who do not produce it, although the producer may take it under the same regulations that apply to others. Before the sportsman can enter upon private land to hunt or fish, he should be willing to pay something to the landowner for the privilege. The return to the landowner will probably have to be high enough to compensate him for the trouble he has shutting gates, repairing fences, and in other ways cleaning up after the harvest is done. What is more, it must com-

pensate him for some of the care he has taken to produce the crop. This return must be tangible, and show up on the black side of the ledger.

The economic value of wildlife is as much or more in the harvesting—hunting or fishing—as it is in the utilization of the crop after harvest. In some places sportsmen now pay individual farmers directly for the privilege of hunting or fishing on their land. There are also groups of farmers organized especially to sell permits for hunting on a large block of farms, the return divided among the individual farmers and used for employment of special wardens and for other expenses. In some instances the State Conservation Departments are attempting to compensate farmers by providing seed, fertilizer, fencing materials, or other subsidy. However it is done, the farmer must ultimately obtain a direct economic return for the hunting and fishing permitted on the land he owns and operates. He must also have assurance that the harvesting of the game does not damage his tilled crops, his woods, or the physical plant which is his farm.

The sportsman harvests a crop when he shoots quail in a field, as much as if he were picking apples in an orchard. He would not take apples without paying for them. The quail is a result of the way the land was used just as the apples are a product of the orchard and the way it was managed. Even with fishing in streams or hunting game of large cruising radius, where the animals wander habitually from one area to another, the problem is the same. It is brought into focus, however, on an individual operating unit of land such as a farm. When the land operator is reimbursed for the wildlife crop, he is more likely to be willing to permit its harvesting. Even though reimbursing the producer may mean additional fees paid on the part of the sportsman—fees which reach the land operator's purse or provide him with something he can count an economic asset—it seems the only reasonable way to solve what is fundamentally a complicated and difficult problem.

The total value of wildlife is not to be reckoned alone in its harvest. The dividends add up to more than sport, meat, and fur. Many species of fish, birds, and mammals are unknown to any except those who specialize in a knowledge of them. Yet these many forms are not without real value. Some of them provide food for the species we do harvest. Most of them play an often unrecognized part in the intricate complex of living things from which man cannot separate himself, however hard he may try. Wild animals are a part of our cultural heritage. As stated in the preface of this work, we want wildlife not only for the economic, aesthetic, and recreational values it embodies, but because it is an expression of a national house in good order. Where it thrives, we know the land is well looked after. A landscape without wildlife is like a play with an important character missing.

XIV ⇛ WILDLIFE, LAND, AND PEOPLE

To SAY that wildlife cannot be managed properly except as it relates to land use is but another way of stressing the dependence of wildlife upon environment. Broadly speaking, the condition of the land determines the very occurrence of wild animals. Animal life varies from place to place, from one condition to another. The farm woodland, the dense forest, the plains, the marsh, every habitat has its characteristic forms of living creatures. Food, cover, water, length of day, slope exposure—all these and many other environmental factors help to determine kinds and numbers of wild animals.

Today's environment is the result of severe modification by man and his ways of using the soil, waters, forests, and other elements that go to make up the land. To a very large extent, attempts to relate wild animals to their environment is now a matter of relating them to man's activities (Plate 31). For that reason wildlife must be considered, not as a resource to be managed separately, but as a product of its environment intimately dependent upon what man does with the land.

The relation of land use to wildlife has been recognized by many whose primary interests are not biological. It was expressed by Henry A. Wallace, then Secretary of Agriculture (Holt and Van Dersal 1942), as follows:

Wild creatures, like ourselves, are dependent on the land, and if we are to continue to have them with us, we must see to it

that enough land is theirs too. I mean this in a very broad sense. We should set aside many areas that are especially suited to wildlife—but beyond this we shall need to see that all our land programs take wildlife into consideration. . . It is my conviction that we shall restore our wildlife to something approaching its former abundance only by devoting more attention to wildlife in connection with all our activities—continuing of course our control of hunting and our provision for sanctuaries, but at the same time making wildlife at home almost everywhere.

It may be a long time before all of our lands are properly managed. Somehow we do not usually do as well as we know how. Therefore, to the sportsman and wildlife enthusiast, it may seem hopeless to wait upon better land management for better wildlife. Yet there are cold considerations that almost demand that we place our greatest reliance in the hands of those who administer or operate the American land. Appropriate as they may have seemed, laws and regulations, predator control, stocking of pen-raised animals, and many other rules and activities have not done the required job. Past experience urges us, rather, to look to fundamentals. Today, dependence upon the land and what is done by those who use it is the first rule of wildlife management.

It is well to remind ourselves that there is a great deal we do not know about the relation of land use to wild creatures. A good deal is already known about many conservation practices, but we are constantly learning more by trial and experience. As there are things to be learned about conservation practices and how best to apply them, so there is much to be learned about wildlife in relation to such practices. The conservation measures outlined in these chapters are proving to be good for the land and profitable to the farmer or rancher. Observation indicates that they are equally good for wildlife. The influence upon fish, birds, and mammals of each conservation practice treated here has been discussed so far as it is known.

What we know is usually based upon limited experience. Much

of our practical knowledge of wild creatures is gleaned from studies and experiments not originally intended to solve specific problems in land-management biology. Hence it is often fragmentary, partially adaptable to problems at hand, or useful only after we have patched together odd and diverse bits of information. There is growing need for research on how land-use practices influence populations of wild animals, because the practices, to be fully successful, must be biologically sound (Graham 1945). Until we know whether the kinds of wild creatures increased by conservation practices are likely to be harmful or beneficial, we cannot recommend such practices without reservation.

There is also a need to bring to bear upon the conservation of any single natural resource the thinking of men trained in various fields. The desirability of accomplishing conservation through the united effort of a combined staff of technically trained men has never been better stated, or subsequently followed more effectively, than by the Chief of the United States Soil Conservation Service. In 1934, when the national program of soil conservation was in its infancy, Hugh H. Bennett made a call for practical erosion control. After pointing to the problem and the need for the land operator himself to materialize the work, he wrote:

Here is the first attempt in the history of the country to put through large scale, comprehensive erosion and flood control projects, applying to complete watersheds from the very crest of the ridges down across the slopes to the banks of streams and thence to their mouths. These are not engineering projects or forestry projects or cropping projects or soils projects or extension projects, but a combination of these, with other specialized activities where needed, operated conjointly with such reorganization of farm procedure as the character of the land indicates as being necessary. This procedure is based on the best information in the possession of scientific agriculturists:—the agronomist, forester, range specialist, agricultural engineer, economist, extension specialist, game specialist, geographer, and others. It is the application of accumulated knowledge pertaining to the great multi-

plicity of variables affecting the three-phase process of absorption, runoff and erosion, employed not as single uncoordinated implements of attack, but collectively, according to the needs and adaptability of the land, in a combination of integrated control measures, to be supplemented where necessary by new information accruing from the experience of combat.

Dr. Bennett's inspiring challenge is being met in soil conservation. It will be met also in the conservation of wildlife and of every other resource that relates to the land and the things the land supports. It must be met before we can intelligently treat renewable natural assets or insure their proper use and preservation.

We are conscious in the world today of what it costs to do things. The great expenditures and enormous loans of the war period only emphasize the question of where the money ultimately is to come from. Perhaps one reason there is so much concern with conservation is our tardy realization that wealth and natural resources are virtually the same. Without resources, a nation is poor. Nations have been spending at a fabulous rate, and their natural resources have been reduced accordingly. Whether renewable or not, resources cannot safely be squandered. Conservation and waste are incompatible. Waste in producing and utilizing wildlife, like every other resource, is inconsistent with its conservation.

We are prone to forget that the wealth of nations depends as much upon the resources of nature as upon the courage and resourcefulness of men. When that 'wealth' has resulted in destroyed forest or exploited wildlife, it has been ill-gotten gain. When that 'wealth' represents impoverished soil in Africa, Australia, and the Americas—a soil less able now to support us than it once was—it represents the decimation of natural resources akin to the killing of the goose that laid the golden egg. Our welfare—individual and social—is still rooted in the resources of which the world environment is the sum. How we have used them and how we shall in the future use them determines, as

much as anything else, how prosperous we can be. Life is much more a matter of ecology than it is an expression of economics.

In the modern world it is somehow difficult to think of our lives and the things we do as biological processes. We are surrounded by mechanical devices, and depend on gadgets. Water from a faucet, food from a grocery shelf, waste disposal at the flip of a lever, light from a switch, warmth from an automatic furnace—all such things tend to distort the realities of daily living. Not only our individual lives, but society itself has become so involved with its own activities that the things upon which life depends are often forgotten. Passing expediency often blinds us to the fundamentals.

In his philosophical essays, Aldo Leopold (1939) has expressed the contrast between the mechanical and the biological understanding of the things about us. He writes:

No one dreamed, a hundred years ago, that metal, air, petroleum, and electricity could coordinate an engine. Few realize today that soil, water, plants, and animals are an engine, subject, like any other, to derangement. Our present skill in the care of mechanical engines did not arise from fear lest they fail to do their work. Rather was it born of curiosity and pride of understanding. Prudence never kindled a fire in the human mind: I have no hope for conservation born of fear. The 4-H boy who becomes curious about why red pines need more acid than white is closer to conservation than he who writes a prize essay on the dangers of timber famine.

Both the co-ordinated approach to a solution of conservation problems and dependence upon fundamental biological knowledge are involved in such thinking.

Conservation was at one time synonymous with preservation. To conserve the forest was to keep it in its existing condition. There is a definite but limited need for conservation in this sense. Certainly we want to preserve intact forever the scenic splendors of the National Parks. Any change wrought by man to these areas is desecration. We also need wilderness areas preserved inviolate

—wilderness in the sense of undisturbed natural communities of plants and animals. There should be preserved reasonably large tracts of every important type of forest, grassland, and other natural community that ever existed in the United States. We need them not for curiosity but for the very practical reason that we should have natural points of reference for the things we do with the land. We cannot sensibly manage a forest in a region where we have no concept of the highest type of forest the natural conditions of the region can support. The same is true of grazing land, wildlife land, and cultivated areas.

What has happened in the Black Belt of Alabama illustrates how important it is to practice a type of land use in keeping with natural conditions. This area was originally a tall-grass prairie existing on calcareous soils in a region where the vegetation was predominantly forest on acid soils. After the South was settled, however, cotton was grown everywhere. The dark, rich Black-Belt soils seemed one of the best for cotton, which was grown with great profit for some time. But the clean cultivation required for cotton raising permitted excessive soil loss, until today the black soils of the Black Belt are gone, exposing the light-colored subsoil which is generally now the surface soil. Cotton grew more poorly as the years passed, and here and there Johnson grass, an exotic weed, the pasture value of which was only recently recognized, began to appear and to take over many of the cotton fields. Eventually, to hold what was left of the soil and to save the fields for productive use, soil conservationists encouraged pasture and hay development.

Today the Black Belt is fast becoming devoted to livestock raising, a use in keeping with its natural capacity. The lesson is that most permanent profit can usually be made from land only when it supports vegetation and use consistent with its natural capacities. In the case of the Black Belt, the production of livestock from pasture grasses—a type of vegetation comparable to the prairies originally occurring there—seems the best for the land and for man.

For many areas we have little idea of the original or climax vegetation and the animal life associated with it. If we had, our sights could be adjusted better for the future optimum use of the land. It is for such purpose, among others, that the preservation of natural areas is required. Every undisturbed park, wilderness area, or other tract of land preserved in its original or pre-settlement condition is worth all it costs, as an ecological check on what is being done on adjacent or comparable areas.

For the most part, however, conservation today means not preservation but 'wise use.' This is a reasonable objective, for renewable resources such as soil, water, trees, grass, and wildlife can be both used and preserved. They are subject to management. Living things produce a surplus over that needed to perpetuate them in good thrift. Man can make use of this surplus. We need only substitute for exploitation a program of careful use, of husbandry. This we are learning to do more and more capably. We must learn to do it or suffer in loss of wealth, health, and social order. To care for the things we use, to substitute frugality for waste, is a major problem facing all of us, not only in our own country but everywhere.

Perhaps such an approach brings us to what we really mean by conservation. Conservation is not alone something we do, it is something we feel. It is very close to the respect, kinship, and awe with which primitive man looked upon the rain, trees, and wild animals that helped to create the habitat in which he lived. Conservation brings us face to face with the realities of environment. When conservation becomes a kind of thinking, a way of life, it takes on real and substantial meaning. If we act prudently instead of wantonly when we deal with our natural resources, we shall be living conservatively. After all, conservation is little more than living within our means.

When we have learned to conserve the land and, in our use of it, handle every unit and every parcel in accordance with its capacity for use, we shall have contributed materially to the benefit of our nation's wildlife. For when all is said and done, it is

a home that wildlife needs above all else: a place to feed, hide, raise its young, sleep, play, and seek shelter. The way we manage the land determines whether wildlife shall have a place. The land-use practices described in this book are believed to be some of those that provide a place for wildlife as an integral part of the new land pattern that is taking shape. When we have accomplished land conservation, we shall have gone a long way toward achieving wildlife conservation.

BIBLIOGRAPHY

THE following list consists largely of references cited in the text. Some pertinent writings not cited have been added but there are, of course, many other articles of interest in the way of land-management biology that are not included. The student will want to look into State Conservation Department publications, especially the *Pennsylvania Game News, Missouri Conservationist, Minnesota Conservation Volunteer,* and *Wisconsin Conservation Bulletin.* Annual reports and other publications of Federal conservation agencies, especially the Soil Conservation Service, Forest Service, and Fish and Wildlife Service, give much material of interest. The official organ of the Soil Conservation Service, *Soil Conservation* magazine, has many appropriate articles, with the March 1939 and April 1942 numbers devoted entirely to soil-wildlife conservation measures. The annual *Transactions of the North American Wildlife Conferences,* published by the Wildlife Management Institute, and the quarterly issues of the *Journal of Wildlife Management,* published by the Wildlife Society, also contain contributions, many of which are cited.

Allan, Philip F. 1944. 'Fur from Farm Lands.' *Soil Conservation,* 9:256-61, 283-6. A popular discussion of land-use practices that improve farm habitat for furbearer production.

Allan, Philip F., and Davis, Cecil N. 1941. *Ponds for Wildlife.* U. S. Dept. Agr. Farm. Bul. 1879. 46 pp. Discusses pond-management measures in relation to soil conservation, with emphasis on the use of aquatic vegetation.

BIBLIOGRAPHY

Allen, Durward L. 1943. *Michigan Fox Squirrel Management.* Mich. Dept. Cons. Game Div. Publ. 100. 404 pp. An outstanding work on mammal management, with ample consideration of its relationship to history and use of the land.

Altpeter, L. Stanford. 1944. 'Use of Vegetation in Control of Streambank Erosion in Northern New England.' *Jour. Forestry,* 42:99-107. Presents specific directions for the establishment of willows and other plants on streambanks, based on work in Vermont.

Anderson, Wallace L. 1942. 'Adolph Lee Looked Ahead.' *Soil Conservation,* 7:251. A note on the effect of five years of conservation farming on bird numbers on a Wisconsin farm.

——. 1945. *Biology Handbook.* 2nd ed. U.S. Soil Conservation Service Upper Mississippi Region. 83 pp. Processed. Includes specific recommendations for establishing soil- and water-conservation practices of particular value to wildlife.

Beard, Daniel E., *et al.* 1942. *Fading Trails: The Story of Endangered American Wildlife.* Macmillan. 279 pp. Includes chapters on species of animals whose numbers are materially reduced.

Beck, Thomas H.; Darling, Jay N.; and Leopold, Aldo. 1934. *Report of the President's Committee on Wildlife Restoration.* U.S. Dept. Agr. unnumbered publ. 27 pp. Primarily a recommendation that lands be purchased for restoration of various kinds of wildlife.

Bellrose, Frank C., Jr. 1945. 'Relative Values of Drained and Undrained Bottomland in Illinois.' *Jour. Wildl. Mangt.,* 9:161-82. Analysis of cost of drainage and flood-control operations and value of undrained areas for shooting, fishing, and production of furbearers.

Bennett, H. H. 1934. 'A Major Effort at Erosion Control.' *The Land: Today and Tomorrow,* October: 1-4, 20-21. A first year's report on the national erosion-control program, with a statement of the challenge ahead and how it will be met through co-ordination of technical efforts.

——. 1939. *Soil Conservation.* McGraw-Hill. 993 pp. A standard text on the subject, with a chapter on wildlife.

——. 1942. 'Total Conservation.' *Soil Conservation,* 7:233-5. A brief article stating the first estimate of the amount of wildlife land on farms and ranches.

——. 1944. 'How Soil Conservation Aids Wildlife.' *Audubon Mag.,* 46: 77-86. A popular summary of the influence of soil conservation upon bird numbers.

Bennitt, Rudolf. 1941. *Principles of Wildlife Conservation.* 143 pp. Processed. Syllabus of a course in zoology at the University of Missouri.

Blackstone, Sir William. 1783. *Commentaries on the Laws of England.* 9th ed. W. Strahan, London. 4 vols. Classical work by the father of English law, with notes on game.

Bond, Richard M. 1945. 'Range Rodents and Plant Succession.' *Trans. Tenth North Amer. Wildl. Conf.,* 229-34. Review of ecological studies of

range rodents and their relation to types of vegetation, with the suggestion that small mammals under certain conditions may actually assist in the recovery of deteriorated range land.

Bourne, Edward Gaylord. 1922. *Narratives of the Career of Hernando de Soto in the Conquest of Florida, as Told by a Knight of Elvas, and in a Relation by Luys Hernandez de Biedma, Factor of the Expedition.* Allerton Book Co., N. Y., 2 vols. One of the many chronicles of Spanish exploration in America. The Spaniards were little interested in natural history and their journals have few wildlife references.

Bradbury, Harold M. 1938. 'Mosquito Control Operations on Tide Marshes in Massachusetts and Their Effect on Shore Birds and Waterfowl.' *Jour. Wildl. Mangt.*, 2:49-52. A study of the 1300-acre Duxbury marsh, with the conclusion that mosquito-control operations are not incompatible with migratory waterfowl restoration work.

Brown, Carl R. 1943. *The Control of Reservoir Silting.* U.S. Dept. Agr. Misc. Publ. 521. 166 pp. An outstanding publication on the subject. It includes a note on establishing vegetation for wildlife on otherwise wasted areas of land in order to complete erosion-control treatment of watersheds.

Cameron, Jenks. 1929. *The Bureau of Biological Survey: Its History, Activities and Organization.* Brookings Inst. Govt. Research, Service Monographs of the U.S. Govt. No. 54. 339 pp. A comprehensive analysis of the development and work of the Biological Survey to the date of publication.

Chapman, A. G. 1944. *Forest Planting on Strip-mined Coal Lands with Special Reference to Ohio.* Central States Forest Expt. Sta. Tech. Paper 104. 25 pp. Mimeo.

Clayton, C. F. 1934. 'Land Use Planning and the Game Crop.' *Trans 20th Amer. Game Conf.*, 97-110. Points to the need for fitting preservation of wildlife resources into the whole pattern of conservation.

Columbus, Christopher. 1924. *Journal of First Voyage to America by Christopher Columbus.* Albert and Charles Boni, N. Y. 251 pp. With an introduction and in part abridged by Van Wyck Brooks. There are sparing references to wildlife in the narrative.

Compton, Lawrence V. 1939. 'Wildlife and the Range.' *Soil Conservation*, 4:215-17. General comments on the interrelationship between wildlife welfare and management of western range lands.

——. 1943. *Techniques of Fishpond Management.* U.S. Dept. Agr. Misc. Publ. 528. 22 pp. A review of knowledge of fish management in small ponds, with emphasis on fertilization.

Compton, Lawrence V., and Hedges, Frank R. 1943. 'Kangaroo Rat Burrows in Earth Structures.' *Jour. Wildl. Mangt.*, 7:306-16. An illustrative study made in Arizona showing that design of engineering structures can reduce damage by burrowing mammals.

Connery, Robert H. 1935. *Governmental Problems in Wild Life Conservation.* Columbia Univ. Press. 251 pp. Treats organization and functions of Federal and state wildlife agencies, with emphasis on legal aspects of the subject.

Cooperider, Charles K., and Hendricks, Barnard A. 1937. *Soil Erosion and Stream Flow on Range and Forest Lands of the Upper Rio Grande Watershed in Relation to Land Resources and Human Welfare.* U.S. Dept. Agr. Tech. Bul. 567. 88 pp. Offers the suggestion that wildlife production may be one of the most desirable uses of the watershed.

Dambach, Charles A. 1942. 'Fence Row Facts.' *Soil Conservation,* 7:238. A note on Ohio studies that show shrubby fence rows support numbers of beneficial insects, birds, and mammals.

——. 1944. 'A Ten-Year Ecological Study of Adjoining Grazed and Ungrazed Woodlands in Northeastern Ohio.' *Ecol. Monog.,* 14:255-70. Considers soil condition, vegetation, invertebrates, birds, small mammals, and maple-sugar production in relation to woodland condition.

——. 1945. 'Some Biologic and Economic Aspects of Field Border Management.' *Trans. Tenth North Amer. Wildl. Conf.,* 169-84. Discusses various kinds of field-border vegetation in Ohio and the insects, birds, and mammals that occupy them.

Dambach, Charles A., and Good, E. E. 1940. 'The Effect of Certain Land Use Practices on Populations of Breeding Birds in Southwestern Ohio.' *Jour. Wildl. Mangt.,* 4:63-76. Report of studies that show effect of strip cropping and other soil-conservation practices on populations of ground-nesting birds.

Darby, H. C. 1940. *The Draining of the Fens.* Cambridge University Press, London. Bentley House, N. Y. 312 pp. A discussion of drainage on the English plain, with comments on early controversy between those interested in wildlife and others.

Darling, J. N. 1934. Statement of Hon. Jay N. Darling, Chief, Bur. of Biol. Survey, Dept. Agriculture (8 May 1934), in *Hearings before the Select Committee on Conservation of Wildlife Resources,* House of Rep. 73rd Cong., pp. 1-18, 101-18, 153-8. The report includes one of the earliest references to the desirability of correlating erosion control and wildlife-management practices.

Darling, J. N.; Sheldon, H. P.; and Gabrielson, I. N. 1936. *Game Management on the Farm.* U.S. Dept. Agr. Farm. Bul. 1759. 22 pp. Treats wildlife-habitat improvement as a result of establishing erosion-control cover.

Davison, Verne E. 1939. *Protecting Field Borders.* U.S. Dept. Agr. Leaflet No. 188. 8 pp. Brief specifications for planting eroding field margins in the Southeast for erosion control and wildlife.

——. 1940. *Shrubs for Wildlife on Farms in the Southeast.* U.S. Dept. Agr. Leaflet No. 200. 8 pp. A short general discussion of the use of shrubs as part of a soil-conservation program.

Davison, Verne E. 1941. 'Wildlife Borders—An Innovation in Farm Management.' *Jour. Wildl. Mangt.*, 5:390-94. Discusses the treatment of the planted and managed borders between crop field and woodlot, and states that they are a part of the new land-use pattern in the Southeast.

——. 1942a. 'Thirty Million Acres of Undiscovered Wildlife Land in the United States.' *Trans. Seventh North Amer. Wildl. Conf.*, 366-74. An article on recognition and treatment of the types of agricultural land adapted best to the production of wildlife.

——. 1942b. 'Bobwhite Foods and Conservation Farming.' *Jour. Wildl. Mangt.*, 6: 97-109. Suggests farming practices most likely to provide food for bobwhite as indicated by analysis of nearly 6000 quail crops.

——. 1945. 'Wildlife Values of Lespedezas.' *Jour. Wildl. Mangt.*, 9:1-9. A summary of what is known about establishing perennial lespedezas in the Southeast, with comments on their use by wildlife for food and cover.

Davison, Verne E., and Johnson, J. A. 1944. *Fish for Food from Farm Ponds.* U.S. Dept. Agr. Farm. Bul. 1938. Rev. 22 pp. A practical guide for building, stocking, and fertilizing fishponds.

Denney, Arthur H. 1944. 'Wildlife Relationships to Soil Types.' *Trans. Ninth North Amer. Wildl. Conf.*, 316-23. Report of studies showing a positive correlation of weight of Missouri rabbits and raccoons with soil types. It notes use of soil types as a basis for game range classification.

Dickerson, L. M. 1939. 'The Problem of Wildlife Destruction by Automobile Traffic.' *Jour. Wildl. Mangt.*, 3:104-16. Observations and comments on wildlife mortality on highways.

Edminster, Frank C. 1938. 'The Farm Fence in Wildlife Management and Erosion Control.' *Trans. Third North Amer. Wildl. Conf.*, 583-91. Discusses the relation of wildlife to fencerows in the Northeast, with special reference to populations of ring-necked pheasants.

——. 1939a. 'Hedge Plantings for Erosion Control and Wildlife Management.' *Trans. Fourth North Amer. Wildl. Conf.*, 534-41. States land-use advantages of hedges and discusses plant species most appropriate for planting in them.

——. 1939b. 'Improving Farm Woodland for Wildlife.' *Soil Conservation*, 4:212-14, 223. General discussion of treatments recommended and kinds of wildlife benefited.

——. 1942a. *Wildlife Management through Soil Conservation on Farms in the Northeast.* U.S. Dept. Agr. Farm. Bul. 1868. Rev. 53 pp. A useful bulletin presenting practical recommendations for establishment of land-use measures valuable to wildlife.

——. 1942b. 'More Ruffed Grouse from Woodland Management.' *Soil Conservation*, 7:261-2. A brief article suggesting management recommendations.

Eschmeyer, R. W. 1944. 'Harvesting the Fish Crop.' *Trans. Ninth North Amer. Wildl. Conf.*, 202-11. Basing his conclusions on experience with

Tennessee Valley Authority lakes, the author contends that most of the fish crop is unharvested and unused and calls for revamping of regulations.

Foote, Leonard E. 1945. *The Vermont Deer Herd: A Study in Productivity.* Vermont Fish and Game Service, State Bul. P-R Series 13. 125 pp. A thorough study which includes comments on deer numbers in relation to use of the land.

Fry, J. R., Jr. 1938. 'Willows for Streambank Control.' *Soil Conservation,* 4:109-11, 128. Discusses vegetative treatment used in Wisconsin.

Gabrielson, Ira N. 1942. *Wildlife Conservation.* Macmillan. 250 pp. A popular, authoritative book, with some chapters on the relation of other kinds of conservation to wildlife.

——. 1943. *Wildlife Refuges.* Macmillan. 257 pp. A comprehensive report on North American wildlife refuges, with a bibliography.

Garretson, Martin S. 1938. *The American Bison: The Story of Its Extermination as a Wild Species and Its Restoration under Federal Protection.* New York Zoological Society. 254 pp.

George, Ernest J. 1936. *Growth and Survival of Deciduous Trees in Shelterbelt Experiments at Mandan, N. Dak., 1915-34.* U.S. Dept. Agr. Tech. Bul. 496. 48 pp. Report on a study of twenty-year-old experimental plantings, and recommendations based upon them.

Gerstell, Richard. 1942. *The Place of Winter Feeding in Practical Wildlife Management.* Pa. Game Comm. Res. Bul. No. 3. 121 pp. A thorough and critical analysis of winter feeding as a wildlife-management practice.

Good, E. E., and Dambach, C. A. 1943. 'Effect of Land Use Practices on Breeding Bird Populations in Ohio.' *Jour. Wildl. Mangt.,* 7:291-7. Report of studies showing increased bird numbers as a result of strip cropping in ungrazed woods and well-managed pastures.

Gorsuch, David M. 1934. *Life History of the Gambel Quail in Arizona.* Univ. Ariz. Bul. 5; Biol. Sci. Bul. 2. 89 pp. Includes management suggestions in keeping with proper farm and range-land use.

Gottschalk, L. C. 1944. 'Sedimentation in a Great Harbor.' *Soil Conservation,* 10:3-5, 11-12. Popular summary of an extensive investigation into the siltation of the harbor at Baltimore, Maryland.

——. 1945. 'Effects of Soil Erosion on Navigation in Upper Chesapeake Bay.' *Geogr. Rev.,* 35:219-38. An interesting account of the history of siltation in the Bay and its relation to land use.

Graham, Edward H. 1941a. *Grasses in the Conservation of Soil and Wildlife.* U.S. Dept. Agr. Soil Conservation Service. 19 pp. Mimeo. Narrative tabulation of the wildlife use of grasses important in soil-conservation operations in the United States.

——. 1941b. *Legumes for Erosion Control and Wildlife.* U.S. Dept. Agr. Misc. Publ. 412. 153 pp. A compilation of wildlife uses and soil-conservation values of leguminous plants, both native and introduced, in the United States.

Graham, Edward H. 1943. 'Land Classification as a Technique on Wildlife Management.' *Trans. Eighth North Amer. Wildl. Conf.*, 360-69. Suggests use of land classes for determining most appropriate application of land-use practices valuable to wildlife.

——. 1944. *Natural Principles of Land Use.* Oxford Univ. Press. 274 pp. A book built on the premise that biological concepts can contribute importantly to the wise use and management of land.

——. 1945. 'Frontiers in Land Use Biology.' *Soil Conservation*, 10:193-7. Points to the need for research on land-use practices to determine their wildlife values.

Grange, Wallace B., and McAtee, W. L. 1934. *Improving the Farm Environment for Wild Life.* U.S. Dept. Agr. Farm. Bul. 1719. 62 pp. One of the first articles to stress the wildlife value of erosion-control practices.

Hall, C. C. (editor). 1910. *Narratives of Early Maryland* 1633-1684. Scribners. 460 pp. Includes 'A Briefe Relation of the Voyage unto Maryland, by Father Andrew White, 1634' and other early papers on colonial conditions.

Hamilton, C. L., and Jepson, H. G. 1940. *Stock-Water Developments: Wells, Springs, and Ponds.* U.S. Dept. Agr. Farm. Bul. 1859. 70 pp. Provides specifications for constructing ponds and watering facilities on farm and ranch lands.

Headlee, Thomas J. 1945. *The Mosquitoes of New Jersey and Their Control.* Rutgers Univ. Press. 326 pp. Includes discussion of ecological aspects of control.

Herion, George A. 1939. 'River Bank Protection.' *Soil Conservation*, 5:6-9. Discussion of mechanical and vegetative treatment in Arizona and New Mexico.

Hibbard, Benjamin Horace. 1939. *A History of the Public Land Policies.* Peter Smith, N. Y. 579 pp. A comprehensive treatise on the subject.

Hill, R. G., and Bradt, G. W. 1940. *Producing Wildlife by Good Farm Land Use.* Mich. State Col. Ext. Bul. 218. 23 pp. An attractive bulletin on practical land-use measures beneficial to wildlife.

Hockensmith, R. D., and Steele, J. G. 1943. *Classifying Land for Conservation Farming.* U.S. Dept. Agr. Farm. Bul. 1853. 46 pp. A description of the scheme for classifying rural land according to its inherent capacity for use.

Holand, Hjalmar R. 1940. *Westward from Vinland.* Duell, Sloan and Pearce. 354 pp. The story of the Vikings and their pre-Columbian experiences in North America. It includes discussion of the turkey on the 1280 frieze of a German Church.

Holt, Ernest G. 1934. 'Erosion Control and Game Development.' *Trans. 20th Am. Game Conf.*, 177-81. An early article on the practicability of integrating soil and wildlife conservation by a pioneer leader in the subject.

Holt, Ernest G., and Van Dersal, William R. 1942. *Wildlife and Land Use Patterns.* U.S. Dept. Agr. Misc. Publ. 444. 73 pp. Popular, profusely illustrated booklet on the place of wildlife in the land pattern that is developing as a result of modern conservation farming.

Hoyt, W. G., and Ryan, H. J. 1915. 'Gazetteer of Surface Waters of Iowa.' *U.S. Geol. Survey Water Supply Paper,* 345:169-221.

Hulbert, A. E. 1902-5. *Historic Highways of America.* Arthur H. Clark Co. 16 vols. The first volume discusses the influence of the buffalo on routes of our roads and railways.

Jacks, G. V., and Whyte, R. O. 1939. *The Rape of the Earth: A World Survey of Soil Erosion.* Faber and Faber, London. 313 pp. American ed. 1939. *Vanishing Lands,* Doubleday, Doran. 332 pp. Foremost book on the subject, especially the general social and economic effects of erosion. There is a chapter on wildlife.

Jackson, Hartley H. T. 1943. 'Conserving Endangered Wildlife Species.' *Trans. Wis. Acad. Sci. Arts & Letters,* 35:61-89. Discusses extinct birds and mammals as well as those whose futures are in jeopardy, with notes on ways to preserve the latter. There is a bibliography.

Jepson, Hans G. 1939. *Prevention and Control of Gullies.* U.S. Dept. Agr. Farm. Bul. 1813. 60 pp. Largely specifications for control of gullies by both structural and vegetative means.

Jewett, Stanley G. 1943. *Klamath Basin National Wildlife Refuges, Oregon and California.* U.S. Dept. Int., Fish and Wildl. Serv. Wildlife Leaflet 238. 18 pp. Processed. History and description of the refuges.

Kenney, F. R., and McAtee, W. L. 1938. 'The Problem: Drained Areas and Wildlife Habitats.' *U.S. Dept. Agr. Yearbook 1938: Soils and Men,* 77-83. States the problem and cites examples of draining land that would have been more productive if devoted to wildlife.

Komroff, Manuel. 1926. *The Travels of Marco Polo (The Venetian).* Revised from Marsden's translation and edited with introduction by Manuel Komroff. Boni & Liveright, N. Y. 369 pp. Includes remarks on Kublai Khan's game management.

Kraebel, Charles J. 1936. *Erosion Control on Mountain Roads.* U.S. Dept. Agr. Circ. 380. 45 pp. Discussion of methods of stabilizing soil on long, steep road cuts and fills in California.

Langlois, T. H. 1944. 'The Role of Legal Restrictions in Fish Management.' *Trans. Ninth North Amer. Wildl. Conf.,* 197-202. Reprinted in *Wisc. Cons. Bul.,* 9:27-29. 1944. A challenging paper from an authoritative source calling for fewer restrictions on fishing and more emphasis on habitat improvement.

Lay, Daniel W. 1945. 'Muskrat Investigations in Texas.' *Jour. Wildl. Mangt.,* 9:56-76. Life history observations with comments on marsh management and trapping.

Lay, Daniel W., and O'Neil, Ted. 1942. 'Muskrats on the Texas Coast.'

Jour. Wildl. Mangt., 6:301-11. Observations on burning, ditching, and other practices as marsh-improvement measures.

Lehmann, V. W. 1937. *Increase Quail by Improving Their Habitat.* Texas State Game, Fish and Oyster Comm. 44 pp. Largely about practical management, with a section on soil conservation as a habitat influence.

Leopold, Aldo. 1930. 'The American Game Policy.' *Trans. Seventeenth Amer. Game Conf.*, 279-309. A committee statement of principles relating to management of game, game as a crop, sportsman-farmer relationships, and other aspects of the subject.

——. 1931. *Report on a Game Survey of the North Central States.* Sporting Arms and Ammunition Manufacturers' Inst., Madison, Wisc. 299 pp. Probably the first article to point out the feasibility of integrating soil and wildlife conservation.

——. 1933. *Game Management.* Scribners. 481 pp. The standard text on wildlife management.

——. 1937. Review of 'A Survey of the Resident Game and Furbearers of Missouri' by Rudolf Bennitt and Werner O. Nagel. *Jour. Mammalogy*, 18:520-21. The writer of the review takes occasion to question whether anyone will ever get wildlife work done on the land.

——. 1939. 'The Farmer as a Conservationist.' *Amer. Forests*, 45:294-9, 316, 323. Some ecological comments and recognition of the land operator as the one who must accomplish conservation.

——. 1943. 'Wildlife in American Culture.' *Jour. Wildl. Mangt.*, 7:1-6. An essay on the influence of wildlife on American traits, characteristics, and sportsmanship.

Luckenbill, Daniel David. 1927. *Ancient Records of Assyria and Babylonia.* Univ. Chicago Press. 2 vols. Includes translation of inscription on Palace of Nineveh seventh century B.C. that is one of the earliest records of habitat management for wildlife.

McAtee, W. L. 1936. *Groups of Plants Valuable for Wildlife Utilization and Erosion Control.* U.S. Dept. Agr. Circ. 412. 12 pp. Primarily a listing of plants known to be of special value in providing cover, browse, herbage, mast, fruit, or seed for wildlife.

——. 1937. 'Wildlife in Land Planning.' *Pa. Game News*, 8:4-5, 26. Notes on economic value of wildlife and environmental improvement.

——. 1941. *Plants Useful in Upland Wildlife Management.* U.S. Dept. Int. Cons. Bul. No. 7. 50 pp. Much like U.S. Dept. Agr. Circ. 412, with the plants arranged in 10 groups for planting in various regions of the United States.

Miller, J. Paul, and Powell, Burwell B. 1942. *Game and Wild-fur Production and Utilization on Agricultural Land.* U.S. Dept. Agr. Circ. 636. 58 pp. One of the few studies dealing with the economic aspects of game production, with the conclusion that wildlife management is profitable on agricultural land only when it is integrated with other kinds of land management.

Mohr, Carl O. 1943. 'Illinois Furbearer Distribution and Income.' *Bul. Ill. Nat. Hist. Survey*, 22:505-37. Records fur take for most of the ten-year period 1930-40 with values from year to year.

Monson, Gale. 1941. 'The Effect of Revegetation on the Small Bird Population in Arizona.' *Jour. Wildl. Mangt.*, 5:395-7. Shows birds to be about twice as numerous on properly managed range land as on overgrazed.

Morehead, L. B. 1939. 'Willow Mats Halt Streambank Erosion.' *Soil Conservation*, 5:127, 131. Note with diagram of use of willows on Ohio Valley streams.

Mosby, Henry S., and Handley, Charles D. 1943. *The Wild Turkey in Virginia: Its Status, Life History and Management*. Pittman-Robertson Projects—Division of Game, Commission of Game and Inland Fisheries, Richmond, Va. 281 pp. Comprehensive study with comments on the relation of turkey management to forest management.

Moss, A. E. 1939. 'Relation between Take of Upland Game and Agricultural Land Uses in Connecticut.' *Jour. Wildl. Mangt.*, 3:269-78. Shows a relation between the success of pheasant stocking and productivity of the soil.

——. 1942. 'Income Possibilities from a Small Artificial Pond in Eastern Connecticut.' *Jour. Wildl. Mangt.*, 6:141-6. Points to values of wet lands in terms of economic returns from a five-acre pond.

National Conference on Land Classification. 1940. *The Classification of Land*. Proc. First Nat. Conf. on Land Class. Mo. Agr. Expt. Sta. Bul. 421. 334 pp. Numerous papers on many aspects of the subject. There is only passing reference to wildlife.

National Resources Board. 1935. 'Planning for Wildlife in the United States.' Part IX of the *Report on Land Planning*. 24 pp. Discusses need for wildlife areas, with emphasis on refuges and forest wildlife.

National Resources Committee. 1938. *Low Dams: A Manual of Design for Small Water Storage Projects*. 431 pp.

Norton, E. A. 1940. 'Land Classification as an Aid to Soil Conservation Operations.' *Mo. Agr. Expt. Sta. Bul.* 421, pp. 293-304. A discussion of the classification of land according to use capabilities.

Osborn, Henry Fairfield. 1923. *Men of the Old Stone Age: Their Environment, Life and Art*. Scribners. 559 pp. Includes many examples of the influence of wild animals on prehistoric art and culture.

Palmer, T. S. 1912. *Chronology and Index of the More Important Events in American Game Protection 1776-1911*. U.S. Dept. Agr. Biol. Survey Bul. 41. 62 pp. A valuable tabulation of laws and events relating to wildlife.

Penfound, William T., and Schneidau, John D. 1945. 'The Relation of Land Reclamation to Aquatic Wildlife Resources in Southeastern Louisiana.' *Trans. Tenth North Amer. Wildl. Conf.*, 308-18. Points out that less than 1 per cent of the land in drainage projects in the area studied is

now under cultivation and that reflooded projects make admirable habitats for wildlife.

Petrides, George A. 1942. 'Relation of Hedgerows in Winter to Wildlife in Central New York.' *Jour. Wildl. Mangt.*, 6:261-80. Analysis of birds and mammals inhabiting fencerows. It lists the plant species composing them, together with suggestions for fencerow management.

Rawle, William. 1811. 'Advantages of Agricultural Tours on Gleditsia triacanthos, or Honey Locust, Hedges.' *Memoirs of the Philadelphia Society for Promoting Agriculture*, 2:295. One of the many notes in the early publications of the Society that deal with trials and growth of hedge plants.

Roosevelt, Theodore, 1894. *The Winning of the West.* G. P. Putnam's Sons. 3 vols. An interesting history, mostly of Indian wars, with some notes on wildlife.

Rush, W. M. 1940. 'Wildlife Management and Our Big Game Animals.' *Nature Mag.*, 33:29-36. The point is made that wildlife is the interest on the capital stock—the soil—with which the wildlife manager deals.

Scheffer, Paul M., and Bond, Richard M. 1946. 'A Problem of "Antler Room." ' *Soil Conservation*, 11:161-6. A discussion of excessively large numbers of elk in the Cascade Mountains of Washington and their effect upon habitat and upon the agriculture of the near-by Wenas Valley.

Scholz, Harold F. 1935. *Cause of Decadence in the Old Groves of North Dakota.* U.S. Dept. Agr. Circ. 344. 38 pp. Study of shelterbelts established about 1890 and the factors influencing the survival of the species planted.

Shaler, Nathaniel Southgate. 1895. *Domesticated Animals: Their Relation to Man and to His Advancement in Civilization.* Scribners. 267 pp. An excellent work on the subject.

Shantz, H. L. 1940. *Wildlife and Forestry.* U.S. Forest Service. Address before the U.S. Dept. Agr. Graduate School, 20 November 1940. 11 pp. Mimeo. Comments on early English and European rules relating to forest wildlife and on modern forest-wildlife management in the United States.

Simpson, John. 1907. *Game and Game Coverts.* Country Gentlemen's Assoc., London. 84 pp. An early discussion of the relation of wildlife management to agriculture, with recommendations for woodland border plantings and other practices.

Steavenson, Hugh A.; Gearhart, Harry E.; and Curtis, R. L. 1943. 'Living Fences and Supplies of Fence Posts.' *Jour. Wildl. Mangt.*, 7:257-61. Comments on living fences in the mid-West, with emphasis upon the value of multiflora rose.

Stoddard, Herbert L. 1932. *The Bobwhite Quail: Its Habits, Preservation and Increase.* Scribners. 559 pp. A classic study of an American game animal,

including suggestions for the integration of land-use and quail-management practices.

Stoddart, L. A., and Rasmussen, D. I. 1945. *Deer Management and Range Livestock Production.* Utah Agr. Expt. Sta. Circ. 121. 17 pp. Points to the necessity for considering land use as an important factor in the management of big game.

Stoeckeler, Joseph H. 1945. 'Narrow Shelterbelts for the Southern Great Plains.' *Soil Conservation,* 11:16-20. An analysis of one- to three-row shelterbelts nine years old in Oklahoma and Texas, with notes on survival of species used.

Swingle, H. S., and Smith, E. V. 1942. *Management of Farm Fish Ponds.* Ala. Agr. Expt. Sta. Bul. 254. 23 pp. One of many publications by the experimenters whose work has demonstrated how to produce fish in small ponds as a practical part of land management.

Torrey, John. 1858. 'Notice of Several Indigenous Plants Suitable for Hedges.' *Rpt. Comm. Patents,* 1857:239-43. Includes discussion of several species useful in the Southwest.

Tyler, Lyon Gardiner (editor). 1907. *Narratives of Early Virginia,* 1606-1625. Scribners. 478 pp. Includes Captain John Smith's observations on early American wildlife.

U.S. Forest Service. 1935. *Possibilities of Shelterbelt Planting in the Plains Region.* 201 pp. A comprehensive treatment by numerous writers of many aspects of the proposed tree-planting program.

U.S. House of Representatives. 1935-45. 'Conservation of Wildlife.' *Hearings before the Select Committee on Conservation of Wildlife Resources,* published annually. See especially reports of the Soil Conservation Service, which stress the interrelationship of soil and wildlife conservation.

U.S. Senate. 1933. *A National Plan for American Forestry.* U.S. Senate Document 12. 2 vol. 1677 pp. A comprehensive discussion of United States forest management and resources, including fish and wildlife.

——. 1936. *The Western Range.* U.S. Senate Document 199. 620 pp. A comprehensive discussion of the range resources of the United States and their management, including consideration of wildlife. There is a bibliography.

——. 1937. *Wildlife and the Land: A Story of Regeneration.* Special Committee on the Conservation of Wildlife Resources, Senate Comm. Print 75th Congress, 1st Session. 90 pp. Deals largely with the need for more lands for wildlife refuges.

——. 1940. *The Status of Wildlife in the United States.* Report of the Special Committee on the Conservation of Wildlife Resources. U.S. Senate Report 1203. 457 pp. Statements by various Federal agencies on the wildlife aspects of their work.

Van Dersal, William R. 1938. *Native Woody Plants of the United States: Their Erosion-control and Wildlife Values.* U.S. Dept. Agr. Misc. Publ.

303. 362 pp. Tabulation of all native woody species with compilation of their recorded use by wildlife and their value in soil conservation.

Van Dersal, William R. 1940a. 'Environmental Improvement for Valuable Non-game Animals.' *Trans. Fifth North Amer. Wildl. Conf.*, 200-202. Suggests that modern land-use practices will determine welfare of non-game species.

——. 1940b. 'Utilization of Oaks by Birds and Mammals.' *Jour. Wildl. Mangt.*, 4:404-28. A summary of recorded food habits.

Vorhies, Charles T. 1936. 'Rodents and Conservation.' *Nature Mag.*, 28: 363-5, 379. Critical comments, including economic notes, on control of range-land rodents in Arizona.

Vorhies, Charles T., and Taylor, W. P. 1940. 'Life History and Ecology of the White-throated Wood Rat, *Neotoma albigula albigula* Hartley, in Relation to Grazing in Arizona.' *Univ. Ariz. Col. Agr. Tech. Bul.*, 86: 453-529. Includes pertinent comments on the occurrence of range rodents in relation to stages of plant succession.

Wallace, Henry A. 1937. An Address. *Trans. Second North Amer. Wildl. Conf.*, 15-19. Points to the need for attending to wildlife in national land programs.

Warder, John A. 1858. *Hedges and Evergreens: A Complete Manual for the Cultivation, Pruning, and Management of All Plants Suitable for American Hedging, Especially the Maclura, or Osage Orange.* Orange Judd Co. 290 pp.

Whiteford, C. L.; Paschall, A. H.; and Sease, E. C. 1944. *Physical Land Conditions in Muskingum and Guernsey Counties, Ohio.* U.S. Dept. Agr. Soil Conservation Service Physical Land Survey No. 32. 61 pp., map. Includes notes on the classification and treatment of strip-mined areas.

Wiebe, A. H., and Hess, A. D. 1944. 'Mutual Interests of Wildlife Conservation and Malaria Control on Impounded Waters.' *Jour. Wildl. Mangt.*, 8:275-83. Points out that many mosquito-control operations are actually beneficial to wildlife, as shown by work of the Tennessee Valley Authority.

Wight, Howard M. 1933. *Suggestions for Pheasant Management in Southern Michigan.* Mich. Dept. Cons. 25 pp. Includes early reference to integration of wildlife habitat improvements and erosion control.

Winship, George Parker. 1896. 'The Coronado Expedition 1540-42.' *Fourteenth Annual Report of the Bureau of Ethnology*, pp. 329-613. Govt. Printing Office. Contains translation of the narrative of Pedro de Casteñada, the chronicler of the Coronado expedition to the Southwest.

Yeager, Lee E. 1937. 'Naturally Sustained Yield in a Farm Fur Crop in Mississippi.' *Jour. Wildl. Mangt.*, 1:28-36. Discussion of economic returns from five years of trapping.

——. 1941. 'Wildlife Management on Coal Stripped Land.' *Trans. Fifth*

North Amer. Wildl. Conf., 348-53. Discusses species of animals to be found and suggests treatment of strip-mined lands.

Yeatter, Ralph E. 1934. *The Hungarian Partridge in the Great Lakes Region.* Univ. Mich. School Forestry and Conservation Bul. No. 5. 92 pp. Includes comments on land use as a habitat influence.

——. 1943. 'The Prairie Chicken in Illinois.' *Ill. Nat. Hist. Survey Bul.* 22: 377-416. A life-history study with notes on management, including relation to farming.

INDEX